PROCEEDINGS

OF THE

THIRTY-THIRD ANNUAL CONVENTION

OF THE

American Railway Engineering Association

HELD AT THE

PALMER HOUSE, CHICAGO, ILLINOIS
March 15 and 16, 1932

VOLUME 33

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BUSINESS SESSION

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The object of this Association is the advancement of knowledge pertaining to the scientific and economic location, construction and maintenance of railways. Its action is not binding upon its members.

TUESDAY, MARCH 15, 1932

MORNING SESSION

The Thirty-third Annual Convention of the American Railway Engineering Association was called to order in the Grand Ball Room of the Palmer House, Chicago, by the President, Mr. L. W. Baldwin, President, Missouri Pacific Lines.

The President:—This is the Thirty-third Annual Convention of the American Railway Engineering Association, and it is now declared open for the transaction of business; this meeting is also the annual session of the Construction and Maintenance Section of Division IV—Engineering, American Railway Association, the meetings being concurrent.

The first order of business is the reading of the Minutes of the last annual meeting. Inasmuch as these Minutes have been printed and a copy furnished each member, the reading of the Minutes will be dispensed with, unless there is objection. Do I hear any objection? There being none, the Minutes stand approved as printed.

ADDRESS OF PRESIDENT L. W. BALDWIN

The Thirty-second year of existence of the American Railway Engineering Association has drawn to a close. It has been a year to try the souls of men and organizations. This Association has come through the year in splendid shape. Reports of the various Committees and officers will give eloquent testimony to the constructive contribution to the engineering profession in general, and to the railroads in particular.

This Association was created here in Chicago thirty-three years ago by a small group of railroad men who had a big vision of the possibilities of such an organization. Their judgment and foresight have been justified many times. There are few, if any, organizations in existence to-day which function more successfully or accomplish greater results than the American Railway Engineering Association. The plan of organization and the method of operating it has been demonstrated successfully beyond question for many years. The work of the members and the Committees has resulted in establishing accepted recommended practices that have contributed largely toward the ability of the railroads to weather such storms as the economic disturbance that has existed over this country for the past two years. Their efforts have broadened the possibilities of the engineering profession generally, and contributed much to the welfare of society.

The first purpose and necessity of railroads is to provide adequate, economical and efficient transportation. The ability of railroads to so function is dependent upon their organizations, supplemented by knowledge obtained through experience, study, interchange of views and co-operative effort, to which certainly no group has contributed in greater measure than has ours—through this organization.

We are all familiar with and feast upon the publications of our Association, and, I hope, have a full and complete appreciation of their actual and potential value. It is our obligation to use this knowledge to the benefit of the properties or interests we represent, and impart that knowledge and understanding to associates not so fortunate

as to be a part of this group. Indeed, there is inspiration in the thought that the records of this worth-while work well done shall be passed on and made beneficially available to future generations.

While our Association is composed of an essentially conservative and scientific group, frequently timid in expressing diverse opinions, we have always wanted and now want, individually and collectively, a careful and complete study and analysis and a free discussion of all subjects, that we may have, so far as may be, a united judgment as to practices and methods which have been and are to be used.

The members of this organization are responsible for the economical annual expenditure of hundreds of millions of dollars. The factors that govern the expenditures vary with geographic and economic conditions. Topographic and population influences alone are responsible for the widest variance between the North and the South, the East and the West, and the territory in between. And yet in spite of the differing controlling factors, there are many recommended practices that apply everywhere, and the development and application of those practices by this organization can be counted as a major contribution to the advancement of our American civilization.

I shall not attempt to talk about the value of standarization as such, because there is no person in this room who does not have a complete understanding of that. I shall not even attempt to go into detail regarding the value of standardization to the railroads, but I do want to remind you, in passing, that the good influence of this organization, particularly along the lines of recommended practices, has been extended into allied industries and applied to many materials and to methods, as also it has been extended into the field of design, specifications and records.

The methods by which our recommended practices are developed and concluded, are, in my opinion, of primary importance and value. The conclusions of competent experts, set out after most careful study and analysis, experiment and trial, result in the development of practices that are correct and that withstand the test of time.

I believe one of the outstanding contributing reasons for this Association's success is that it has, from its beginning, urged younger men to feel that they might benefit by the contact, work and interchange of knowledge and experience. I urge that this practice be continued, and that such members be given the earliest possible opportunity to serve on one or more of the Committees, which will unquestionably result in mutual benefit.

It is necessary, of course, to alter American Railway Engineering Association recommended practices as conditions change and new necessities arise. My judgment is, being alert to such changed conditions and necessities, that it constitutes the channel through which we have made and will continue to make our greatest contribution to engineering.

It has been unquestionably proved that the application of these recommended practices has resulted in very material and far-reaching economies in methods, construction, maintenance and operation on American railroads. In our accomplishments industry in general has shared in large measure; industry is indebted to our efforts and will continue to be.

From time to time there is voiced a criticism of the railroads on the ground that their policies and practices are wasteful and extravagant. No group of men is better qualified to refute such charges than the members of our Association; and, at a time like this, when the railroads of the Nation are in a measure on trial, it behooves each of us to do everything we can to bring about a better and proper understanding of these questions on the part of the public. All of us have countless opportunities to carry on some very effective missionary work on behalf of the railroads, and I truly believe it is a duty each of us owes to the industry we represent. I am sure that everyone of you will seek

these opportunities—to know that the American people shall come to an understanding of the difficulties confronting the railroads, and of the justification for and importance of proper co-operation, legislation and public support.

As I see it, it is necessary and important that every railroad officer, and particularly officers such as we who, largely, make up the membership of this organization, take an active interest in public affairs. The very nature of the work of our organization calls for leadership, and we all know that leadership, in its final analysis, means the proper handling of the human equation; it should not be confined to our own offices, organization, railroad or interest.

We live in a machine age and we should know the effect of the machine upon the lives, habits, customs and standards of living of the American people.

Every member of this organization owes it to himself and to the industry he represents to inform himself, if he is not already so informed, concerning at least the fundamentals of the related economics affecting railroads.

We should know the cause and effect, both economic and political, of subsidized competition on the highways and the waterways; the effect of the government continually expanding its activity into the field of private business; how the ever-increasing taxation burden must be carried by an ever-decreasing proportion of taxable wealth and value.

Much of this, of course, is outside the official scope of the American Railway Engineering Association, but it takes an analyst to analyze, and I believe this organization is composed of such. Seemingly, therefore, it is incumbent upon those who can analyze these conditions to do so and use their efforts to acquaint others, as millions of people do not have either access to the data, or the training or ability to analyze it; and certainly representatives of selfish interests and the uninformed cannot be expected to present those subjects clearly and fairly to the American people.

So far as this organization is concerned, we need have no fear for its future. We have seen many depressions come and go. Since this Association was organized in 1900 there have been ten annual meetings when economic conditions in the United States were below the average line. Four of these depressions were of major proportions, namely, those in 1907, 1914, 1921, and the present one. All others, such as the minor one that existed at the time our organization was created and the minor disturbances of 1904, 1911, 1919, 1924 and 1927, have come and left very little trace of having existed.

No one realizes better than an engineer that in order to have a depression we must have an elevation on either side of it.

We need only to remember that our railroads are indispensible to this country. That is the fundamental difference between the present situation, in which the railroads are confronted with ruinous competition on every side, and the one that existed three quarters of a century ago when the old forms of transportation were displaced by railroads. In that former era the railroads were more than able to take care of the entire transportation requirements of the Nation.

In the present situation, the new forms of transportation cannot handle the traffic of the country and, throughout the lives of any of us present the railroads will be required to handle the greater volume of it; therefore it is up to us to maintain our railroads at the highest possible peak of efficiency, as well as to do our share in the education of the public to a proper understanding and appreciation of the imperative need of an adequate and dependable railroad transportation (Applause).

REPORT OF THE SECRETARY

March 1, 1932.

To the Members:

The thirty-third annual report on the general affairs of the American Railway Engineering Association is presented in following pages.

The results of the Association's activities during the year just closed are most gratifying. Notwithstanding the continued adverse business conditions, the progress made is in line with the Association's record of achievement of the past thirty odd years.

COMMITTEE-WORK

One of the prime assets of the Association is the sustained interest in committee-work. Committee-work is often performed at considerable personal sacrifice. This attitude of unselfish interest is highly commendable.

The ultimate purpose of committee activities is the acquirements of facts, the interpretation of their significance, and the use of them in solving economic problems; the diffusion of knowledge pertaining to railway engineering and maintenance; and the preparation of specifications, standards, and recommended practice.

The high standards of previous years have been fully maintained in the reports presented for your approval at this annual meeting. The committees deserve praise for their valuable contributions.

The reports submitted cover a total of one hundred and twenty-nine subjects. Elsewhere in this report brief abstracts from the respective reports, indicative of their wide range and comprehensiveness, will be found.

In subsequent pages tables are also given showing the number of members serving on committees, and the roads with which they are affiliated.

Contact with Technical Organizations.—The Association is continuing the policy of collaborating with other technical organizations in the study of problems of mutual concern. Such collaboration is advantageous and is of distinct benefit to the participating associations. A list of the associations with which we have maintained contact is given below:

American Society of Civil Engineers.
American Society for Testing Materials.
American Society of Mechanical Engineers.
American Standards Association.
Chemical Warfare Service, U. S. Army.
Central Committee on Lumber Standards.
Highway Research Board, National Research Council.
Joint Committee on Automatic Train Control.
Joint Committee on Concrete and Reinforced Concrete.
Joint Committee on Grade Crossing Protection.
Joint Committee on Railway Sanitation.
Manganese Track Society.

Mechanical Division, American Railway Association.
Motor Transport Division, American Railway Association.
National Electric Light Association.
National Scalemen's Association.
Portland Cement Association.
Rail Manufacturers' Technical Committee.
University of Illinois Engineering Experiment Station.

PUBLICATIONS

One of the important functions of the Association is the dissemination of knowledge relating to subjects coming within its province. The channels of communication employed to accomplish this purpose are the "Bulletin," the "Proceedings," and the "Manual."

The Bulletin is the medium used for keeping the members periodically informed as to the activities of committees; for the publication of special papers contributed by members and others on subjects pertaining to railway engineering, and pertinent information regarding Association affairs. To date, three hundred and forty-five numbers of the Bulletin have been issued.

The Proceedings form the permanent record of the annual meetings; the committee reports presented; the oral and written discussions, and the final action of the Association. Thirty-two volumes have been issued since the formation of the Association, aggregating some forty thousand pages of timely and useful information on practically all phases of railway engineering and maintenance of way work. This vast accumulation of data is of inestimable value to the railway industry.

The Manual of Recommended Practice is the outstanding achievement of the Association. The Manual is an encyclopedia of railway engineering science and practice, formulated, endorsed and kept up to date by the united efforts of the Railway Engineers of the North American continent. It represents the Association's judgment of the best current practice for Railway Engineering and Maintenance of Way Work.

During the world war, the War Department of the United States Government purchased upwards of 3,000 copies of the Manual for the use of the American Expeditionary Forces abroad.

In May, 1931, the fourth edition of the revised "General Specifications for Steel Railway Bridges," prepared by the Committee on Iron and Steel Structures, was issued in pamphlet form. There has been a gratifying demand for this publication from railway companies, bridge companies, and from educational institutions.

In 1917, the then current version of these specifications was translated into the Spanish language and published under the auspices of the Government of the Argentine Republic for the information of Engineers in South American countries. The introductory to the translation stated that "the specifications referred to exemplify the best modern practice for steel railway bridges."

During the past year, the Bulletin contained, in addition to the committee reports, three valuable and interesting monographs, as follows:

"Tie Renewals as Affected by the Use of Longer-Lived Ties," by W. J. Burton, Assistant to Chief Engineer, Missouri Pacific Railroad.

"A Method for Finding Cost of Work Done in Moving Trains Against Rolling, Curve, and Rise and Fall Resistances," by J. L. Campbell, retired Chief Engineer, Northwestern Pacific Railroad.

"Rail Stresses and Locomotive Tracking Characteristics Found in Tests on the Great Northern Railway," by J. Paul Shamberger and B. F. Langer, of the Westinghouse Electric & Manufacturing Company organization.

Personnel of Committees by Railways—1931

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Uniform General Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Rivers and Harbors	Stresses in Railroad Track	Clearances	Standardization	Maintenance of Way Work Equipment	Waterproofing of Railway Structures	TOTAL
Atchison, Topeka & Santa Fe	3	2	2	2	1	1	1	3	2	1		1	1	1	1	1	1	1		2	3	1		1		1	1	1	1	36
Atlanta & West Point							1																							1
Atlantic Coast Line				1			1				2								1						1			1		7
Baltimore & Ohio	2	1		2	1	2	1	2	1	1	1	1	3	1	2	1	1	2	1	4	2	1			2	2	3	2		42
B. & O. Chicago Terminal			1						1																					2
Buffalo, Rochester & Pittsburgh																												1		1
Bessemer & Lake Erie											1					1				2		1					1			6
Boston & Maine	2	1		1		2		1			2	1		2		1	1	1			1			2			1	2		21
Canadian National			1	2	3	1	1	1		1					1		1	1	1	3		1		1			1	1		21
Grand Trunk Western								1			1								1											3
Canadian Pacific	1	1	1	1	1	1		1		1		1	1	1	1		1					1	1			1		1		17
Central of Georgia			1			1	1										1		1					1				1		7
Central Railroad of New Jersey								1	1		1	1		1				2	1	1	1							1		10
Chesapeake & Ohio	2	3	2	1	3	1	3	1	2		5	1	3	1		2			1	4	2	3	1	1		1	2	3	1	49
Chicago & Illinois Midland																					1	1						1		3
Chicago & Eastern Illinois										1					1							1						1		4
Chicago & Northwestern	1	1		1	1					1	1	1	1		1			1		1								1	1	13
Chicago & Western Indiana					1				1					1						1		1								5
Chicago, Burlington & Quincy	1		2	2	3		1	1	2			1	1		1	1	1			1		1							1	20
Chicago Great Western																1														1
Chicago, Indianapolis & Louisville										1	1											1								3
Chicago, Mil. St. P. & Pacific	1	1	1	1					1				2	1			1	1		1	1	1	1	1				1		17
Chicago, Rock Island & Pacific	1			2	2	1		2	2	1	1	1	3		1		2					1	2		1		1	1	1	26
Chicago Rapid Transit				1																										1
Cleveland Union Terminals																						1								1
Clinchfield																			1											1
Colorado & Southern									1																					1
Delaware, Lackawanna & Western		1	1	1	1	2	1	1					1					1	1	1		1	1		1	1	1	1		18
Delaware & Hudson			1											1					2				1							5
Duluth, Missabe & Northern							1				1													1						3
Denver & Rio Grande Western							1																							1
Elgin, Joliet & Eastern					1						1	1										1								4
Erie	2	2			1	1		1	1				1	1		2			1		1	1		2	1			1	1	20
Florida East Coast	2				1				1			1			1							1		1				1		9

Personnel of Committees by Railways—1931

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Uniform General Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Rivers and Harbors	Stresses in Railroad Track	Clearances	Standardization	Maintenance of Way Work Equipment	Waterproofing of Railway Structures	TOTAL
Fort Worth & Denver City							1																							1
Great Northern			1										1		1		1													4
Illinois Central	1	1	1	2	3	1	1	1	1	2	2	4	2	3			2	2	1	2	2	1	1	1			2	4	1	44
Illinois Terminal														1																1
Indianapolis Union														1																1
Jacksonville Terminal														1																1
Kansas City Southern			1	1									1		1					2	1	1	1							9
Kansas City Terminal										1				1																2
Lake Superior & Ishpeming			1																					1						2
Lehigh Valley								1				1																1		3
Louisville & Nashville	1		2	1	1		1	1						1																8
Maine Central	1					1	1																					1	1	5
Minnesota International						1																								1
Minneapolis & St. Louis																												1		1
Missouri & Illinois											1																			1
Missouri-Kansas-Texas	1	1		1		1		1	1		2	1	2	1	1	1					2	1				1	2	1		21
Missouri Pacific Railroad	3		1	1	1		3	2			2	1	3	1		1			1	1	1			3	1	1	3	2	1	33
Missouri Pacific Lines			1			1			1	2							1		1		2		1		1					11
Mobile & Ohio							1																			1	1			3
Nashville, Chattanooga & St. Louis												1																		1
New York, Ontario & Western											1									1										2
New York Central Lines				1										1		1		1							1					5
Boston & Albany						1			1										1								1			4
Big Four		1	1				1		1		1				2	1					1	1						1		11
Evansville, Ind. & T. H.																			1											1
Michigan Central	2	2			2		1		1	1	1			1				1			1							1		14
New York Central Railroad	2	3	2	1	3	1		1	3	2	2	2	2		3		3	3		1	2	3		2	1	2	1	4	1	50
Peoria & Eastern	1																			1										2
New York, Chicago & St. Louis					1				1		1		1		1				1											6
New York, New Haven & Hartford	1			1		1			1	1	2			2	1			2		1			1	1		1	2	1	1	21
Connecticut Company											1																			1
Norfolk & Western	1			1	1	1	1	1	1				2	1	1		1	1				1	1	1					1	17

Personnel of Committees by Railways—1931

Railroads	Roadway	Ballast	Ties	Rail	Track	Buildings	Wooden Bridges and Trestles	Masonry	Grade Crossings	Signals and Interlocking	Records and Accounts	Rules and Organization	Water Service and Sanitation	Yards and Terminals	Iron and Steel Structures	Economics of Railway Location	Wood Preservation	Electricity	Uniform General Contract Forms	Economics of Railway Operation	Economics of Railway Labor	Shops and Locomotive Terminals	Cooperative Relations with Universities	Rivers and Harbors	Stresses in Railroad Track	Clearances	Standardization	Maintenance of Way Work Equipment	Waterproofing of Railway Structures	TOTAL
Norfolk Southern	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	1	----	----	2
Northern Pacific	----	----	1	1	1	1	----	1	2	----	1	1	3	----	----	1	2	1	----	2	1	----	----	----	----	1	1	----	----	21
Northwestern Pacific	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	1	----	----	----	----	----	----	2
Pennsylvania	1	4	3	4	3	1	2	2	1	2	2	1	3	2	1	3	1	4	----	3	1	1	1	----	2	1	1	2	----	52
Peoria & Pekin Union	----	1	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
Pere Marquette	1	----	----	----	1	----	----	----	1	----	1	----	----	----	----	1	----	----	----	----	1	----	----	----	----	----	----	1	----	7
Reading	----	1	----	1	1	1	----	----	----	----	1	----	1	----	1	1	----	1	----	----	----	1	----	----	----	----	1	----	----	11
Richmond, Fred. & Potomac	----	1	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	3
St. Louis-San Francisco	1	----	----	----	----	----	----	----	1	----	----	----	1	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	4
St. Louis Southwestern	----	----	----	----	----	----	----	----	----	1	----	----	1	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	3
Seaboard Air Line	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	1	1	----	----	----	----	----	3
Soo Line	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	1	----	2
Southern	----	1	----	1	2	----	1	----	----	1	----	1	1	----	----	----	----	----	1	1	----	----	1	----	----	----	----	1	----	12
Southern Pacific	2	1	1	1	1	----	1	1	3	1	----	----	----	1	----	1	3	1	----	1	1	----	1	2	----	1	1	1	----	26
Temiskaming & Northern Ontario	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Term. R. R. Ass'n. of St. Louis	----	----	----	----	1	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
Texas & Pacific	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	1	----	1	----	----	----	----	----	1	----	4
Third Avenue Railway System	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Toronto Terminals	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Union Pacific	1	1	----	2	----	----	----	----	1	1	----	----	1	----	1	----	----	----	----	----	1	----	----	----	----	----	----	1	----	10
Union Railway (Memphis)	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Union Railroad (Pittsburgh)	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	1
United Railway & Electric Co.	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Virginian	----	----	----	----	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Wabash	1	----	1	----	----	1	1	1	1	----	----	1	1	----	----	----	----	----	1	----	2	----	----	----	----	----	----	----	----	11
Wheeling & Lake Erie	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Western Maryland	----	----	----	----	----	----	----	----	1	----	----	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
Western Pacific	----	----	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Non-Railroad Members	2	4	1	2	12	4	2	12	4	1	3	2	1	12	12	7	11	4	4	7	2	5	11	2	10	----	----	----	3	140
Foreign Members	----	----	6	----	2	----	----	----	----	----	----	----	----	----	1	1	----	----	----	----	----	----	----	----	----	----	----	----	----	10
Total	41	36	42	40	57	31	31	41	43	24	44	27	44	45	37	30	36	31	24	47	33	37	29	26	22	14	29	48	15	1004

MEMBERSHIP

The membership list shows a slight loss from the number reported on a year ago. The greater part of the loss in the membership was due to the severe business recession. When times are more propitious, the loss will undoubtedly be more than made up in additions to the membership rolls.

The following table sets forth the present status of the membership:

Members on rolls as of March 1, 1931		2,791
Additions during the year		110
		2,901
Losses by death	45	
Resigned	115	
Dropped	20	180
		2,721
Net Loss	70	
Membership as of March 1, 1932		2,721

Deceased Members.—It is with profound regret that we record the loss by death of 45 members during the past year. Seven of the deceased were Charter Members, and one a Past-President.

These members who have passed on were loyal and faithful, and contributed materially to the welfare of the Association.

Classification of Membership.—The table below gives in condensed form the membership classification in its relation to the respective departments of the railway service:

General Officers Includes Chairmen of Boards, Presidents, Directors, Vice-Presidents, Assistants to President, General and Assistant General Managers	191
Transportation Officers Includes General and Assistant General Superintendents, Division Superintendents, Trainmasters	103
Maintenance of Way and Structures Officers Includes Chief Engineers, Chief Engineers of Maintenance, Engineers Maintenance of Way, Bridge Engineers, Division Engineers, Signal Engineers, Assistant Engineers	1,824
Maintenance of Equipment Officers Includes General Superintendents of Motive Power and other Mechanical Department Officers	22
Traffic Officers	2
Accounting Officers	13
Purchasing and Stores Department Officers	4
Professors in Colleges	60
Miscellaneous Includes Consulting and Civil Engineers, Engineers of Industrial Corporations, Government and Municipal Engineers, etc.	502
Total	2,721

Railway Executives on Membership Rolls.—The Association continues to have the good-will and encouragement of railway managements, as is evidenced by their affiliation with the organization. The Association is duly grateful for this co-operation. The list below gives the names of Railway Executives holding membership in the Association, and roads with which they are connected:

Atchison, Topeka & Santa Fe	W. B. Storey, President
Atlanta, Birmingham & Coast	B. L. Bugg, President
Atlantic Coast Line	L. Delano, Chairman of Board G. B. Elliott, President
Baltimore & Ohio	Daniel Willard, President
Baltimore & Ohio Chicago Terminal	H. B. Voorhees, President
Boston & Maine	E. S. French, President
Canadian National	Sir Henry W. Thornton, Chairman and President
Canadian Pacific	E. W. Beatty, Chairman and President
Central of Georgia	H. D. Pollard, President
Central of New Jersey	W. G. Besler, Chairman of Board R. B. White, President
Chicago, Burlington & Quincy	Ralph Budd, President
Chicago, Rock Island & Pacific	J. E. Gorman, President
Chicago & Eastern Illinois	C. T. O'Neal, President
Chicago & Western Indiana	E. H. Lee, President
Colorado & Wyoming	Arthur Roeder, President
Delaware, Lackawanna & Western	J. M. Davis, President
Dominion Atlantic	Grant Hall, President
Elgin, Joliet & Eastern	S. M. Rogers, President
Erie	C. E. Denney, President
Eureka Nevada	J. H. Sherburne, President
Huntingdon & Broad Top Mountain	J. Bancroft, President
Illinois Central	L. A. Downs, President
Jacksonville Terminal	J. L. Wilkes, President
Kansas City Southern	C. E. Johnston, President
Lehigh Valley	E. E. Loomis, President
Louisville & Nashville	W. R. Cole, President
Minneapolis, St. Paul & Sault Ste. Marie	C. T. Jaffray, President
Missouri-Kansas-Texas	M. H. Cahill, Chairman and President
Missouri Pacific	L. W. Baldwin, President
Montana, Wyoming & Southern	M. A. Zook, President
New York Central Lines	F. E. Williamson, President
New York, Chicago & St. Louis	W. L. Ross, President
New York, New Haven & Hartford	J. J. Pelley, President
New York, Ontario & Western	J. H. Nuelle, President
Northern Pacific	Charles Donnelly, President
Norfolk & Western	A. C. Needles, President
Pennsylvania System	W. W. Atterbury, President
Peoria & Pekin Union	E. I. Rogers, President
Rapid City, Black Hills & Western	F. E. Clarity, President
Reading	A. T. Dice, President
Rutland	P. E. Crowley, President
Sand Springs Railway	T. H. Steffens, President
Savannah & Atlanta Railway	C. E. Gay, Jr., Receiver and General Manager
St. Louis-San Francisco	J. M. Kurn, President
Seaboard Air Line	L. R. Powell, Receiver
Southern Railway System	Fairfax Harrison, President
Southern Pacific	Hale Holden, Chairman Executive Committee A. D. McDonald, Vice-Chairman Executive Committee Paul Shoup, President
Tennessee, Alabama & Georgia	G. H. Burgess, President
Tennessee Central	H. W. Stanley, President
Terminal Railroad Assn. of St. Louis	Henry Miller, President
Toledo Terminal	A. B. Newell, President
Union Pacific	Carl R. Gray, President
Western Pacific	T. M. Schumacher, Chairman Executive Committee

Railways Represented, Mileage and Number of Members.—Statistics covering these features and also the geographical distribution are embodied in this report on subsequent pages.

RAILWAYS REPRESENTED IN THE A.R.E.A., MILEAGE AND NUMBER OF MEMBERS

	Mileage	*Number of Members*
Akron, Canton & Youngstown Railway	171	4
Algoma Central & Hudson Bay Railway	323	1
Alton & Southern Railroad	22	1
Arkansas Railroad Company	20	1
Arkansas & Louisiana Missouri Railway	85	1
Atchison, Topeka & Santa Fe Railway System	13,568	86
Includes Gulf, Colorado & Santa Fe		
Panhandle & Santa Fe		
Atlanta, Birmingham & Coast Railroad	637	4
Atlanta & West Point Railroad	227	1
Atlantic Coast Line Railroad	5,317	18
Baltimore & Ohio Railroad System	5,640	92
Alton Railroad	1,052	4
Buffalo, Rochester & Pittsburgh Railway	602	3
Bangor & Aroostook Railroad	619	3
Bessemer & Lake Erie Railroad	228	7
Bingham & Garfield Railway	40	1
Boston & Maine Railroad	2,090	34
Brantford Steam Railroad	....	1
Burlington-Rock Island Railroad	367	2
Butte, Anaconda & Pacific Railway	65	1
Canadian National Railways	21,926	69
Central Vermont Railway	462	2
Grand Trunk Western Railway	1,448	12
Canadian Pacific Railway	16,040	42
Cedar Rapids & Iowa City Railway	28	1
Central of Georgia Railway	2,021	23
Central Railroad of New Jersey	693	13
Chesapeake Beach Railway	28	1
Chesapeake & Ohio Railway	3,120	103
Chicago & Eastern Illinois Railway	946	5
Chicago, Burlington & Quincy Railroad	9,325	32
Chicago Great Western Railroad	1,495	8
Chicago, Indianapolis & Louisville Railway	652	3
Chicago, Milwaukee, St. Paul & Pacific Railroad	11,353	33
Chicago Railway Terminal Commission	....	1
Chicago Rapid Transit Company	....	2
Chicago, Rock Island & Pacific Railway	7,592	55
Chicago, St. Paul, Minneapolis & Omaha Railway	1,747	2
Chicago Union Station Company	....	1
Chicago, West Pullman & Southern Railroad	31	1
Chicago & Illinois Midland Railway	132	1
Chicago & Northwestern Railway	8,462	14
Chicago & Western Indiana Railroad	71	9
Cincinnati, New Orleans & Texas Pacific Railway	338	1
Cincinnati Union Terminal Company	....	6
Cleveland Union Terminals Company	60	3
Colorado & Southern Railroad	1,038	1
Colorado & Wyoming Railroad	40	1
Columbia & Cowlitz Railway	8	1
Copper Range Railroad	108	1
Danville & Western Railroad	83	1
Delaware & Hudson Company	924	15
Delaware, Lackawanna & Western Railroad	998	24
Denver & Rio Grande Western Railroad	2,562	4
Des Moines Union Railway	28	1
Detroit & Toledo Shore Line Railroad	50	3
Detroit, Toledo & Ironton Railroad	509	2
Dominion Atlantic Railway	305	1
Duluth, Missabe & Northern Railway	568	6
Elgin, Joliet & Eastern Railway	453	6
Erie Railroad	2,560	35
Eureka Nevada Railway	88	1
Florida East Coast Railway	869	11
Fort Smith & Western Railway	250	1
Fort Worth & Denver City Railway	697	3
Georgia & Florida Railroad	502	1
Georgia Railroad	329	1
Great Northern Railroad	8,605	20
Gulf, Mobile & Northern Railroad	733	2
Houston Belt & Terminal Railroad	24	1
Hudson & Manhattan Railroad	9	1
Huntingdon & Broad Top Mountain Railroad & Coal Company	74	1

	Mileage	Number of Members
Illinois Central System	6,762	84
Illinois Terminal Railroad System	578	6
Indianapolis Union Railway	16	2
Interborough Rapid Transit Company	....	2
Interstate Railway	74	1
Jacksonville Terminal Company	51	1
Johnstown & Stony Creek Railroad	3	1
Kansas City Southern Railway	916	16
Kansas City Terminal Railway	26	4
Kentucky & Indiana Terminal Railroad	8	1
Key System Transit Company	135	1
Lake Superior & Ishpeming Railroad	161	1
Lehigh & Hudson River Railway	97	1
Lehigh & New England Railroad	217	4
Lehigh Valley Railroad	1,362	11
Los Angeles Junction Railway	8	1
Louisiana, Arkansas & Texas Railway	202	1
Louisiana & Arkansas Railway	608	2
Louisville & Nashville Railroad	5,280	16
Maine Central Railroad	1,121	6
Portland Terminal Company	....	1
Midland Continental Railroad	69	1
Midland Valley Railroad	363	1
Minneapolis & St. Louis Railroad	1,627	4
Minneapolis, St. Paul & Sault Ste. Marie Railway	4,397	8
Minneapolis Street Railway Company	....	1
Minnesota Transfer Railway	140	1
Mississippi Central Railroad	150	1
Missouri & North Arkansas Railway	368	1
Missouri-Kansas-Texas Lines	3,189	35
Missouri Pacific Lines:		
Gulf Coast Lines	1,173	16
International Great Northern Railroad	1,160	10
Missouri-Illinois Railroad	202	3
Missouri Pacific Railroad	7,451	150
Mobile & Ohio Railroad	1,159	4
Montana, Wyoming & Southern Railroad	34	2
Montour Railroad	57	2
Montreal Tramways Company	....	1
Muncie & Western Railroad	4	1
Nashville, Chattanooga & St. Louis Railway	1,203	4
National Railways of Mexico	6,920	8
Newburgh & South Shore Railway	83	1
New Orleans & Lower Coast Railroad	60	1
New York Central Lines:		
Boston & Albany Railroad	410	14
Chicago Junction Railway	240	1
Cleveland, Cincinnati, Chicago & St. Louis Railway	2,745	41
Indiana Harbor Belt Railroad	120	2
Michigan Central Railroad	1,858	16
Peoria & Eastern Railway	211	2
Pittsburgh & Lake Erie Railroad	231	4
New York Central Railroad	5,743	90
Nicholas, Fayette & Greenbrier Railroad	....	2
New York, Chicago & St. Louis Railroad	1,698	20
New York, New Haven & Hartford Railroad	2,133	33
Connecticut Company	....	1
New York, Ontario & Western Railway	569	4
Niagara Junction Railway	6	1
Norfolk & Western Railway	2,240	21
Norfolk Southern Railway	933	3
Northern Pacific Railway	6,962	47
Northeast Oklahoma Railway	47	1
Northwestern Pacific Railroad	440	2
Oklahoma Railway	155	1
Oregon & Northeastern Railroad	51	1
Pennsylvania Railroad	10,525	75
Long Island Railroad	404	5
Peoria & Pekin Union Railway	168	2
Pere Marquette Railway	2,265	14
Piedmont & Northern Railway	175	1
Pittsburg & Shawmut Railroad	103	1
Pittsburgh & West Virginia Railway	135	2
Pittsburgh, Chartiers & Youghiogheny Railway	23	1
Pittsburgh, Lisbon & Western Railroad	23	1
Pullman Railroad	6	1
Public Service Railroad of New Jersey	40	1
Quanah, Acme & Pacific Railway	126	1
Rapid City, Black Hills & Western Railroad	34	1

	Mileage	Number of Members
Reading Company	1,644	31
Atlantic City Railroad	164	1
Richmond, Fredericksburg & Potomac Railroad	118	3
Rio Grande & Eagle Pass Railway	25	1
Rutland Railroad	413	2
Sacramento Northern Railroad	274	1
Sand Springs Railway	32	2
San Francisco, Napa & Calistoga Railway	46	1
Savannah & Atlanta Railway	147	1
Seaboard Air Line Railway	4,492	24
Southern Railway System	8,051	29
New Orleans & Northeastern Railway	202	1
Northern Alabama Railway	....	1
Southern New England Railroad	....	1
South Brooklyn Railway	9	1
Southern Pacific System	9,130	39
Southern Pacific Company of Mexico	1,370	5
Southern Pacific Lines in Texas & Louisiana	4,722	14
Spokane International Railway	166	1
St. Louis–San Francisco Railway	5,811	11
St. Louis Southwestern Railway	1,914	13
Tela Railroad	244	2
Temiskaming & Northern Ontario Railway	443	1
Tennessee, Alabama & Georgia Railway	95	1
Tennessee Central Railway	296	1
Tennessee Coal, Iron & Railroad Company	....	1
Terminal Railroad Association of St. Louis	62	4
Texarkana & Fort Smith Railway	81	1
Texas & Pacific Railway	1,955	12
Texas Pacific–Missouri Pacific Terminal Railroad of New Orleans	10	2
Texas Electric Railway	230	1
Toledo & Western Railroad	79	2
Toledo, Peoria & Western Railroad	239	1
Toledo Terminal Railroad	29	3
Toronto, Hamilton & Buffalo Railway	111	1
Toronto Harbor Commission	....	1
Toronto Terminals Railway	....	3
Trinity & Brazos Valley Railway	....	1
Union Pacific System:		
Los Angeles & Salt Lake Railroad	1,230	12
Oregon Short Line Railroad	2,549	8
Oregon–Washington Railroad & Navigation Company	2,365	4
Union Pacific Railroad	3,765	30
Union Railroad (Pittsburgh)	46	2
Union Railway (Memphis)	18	3
Union Terminal Company (Dallas)	16	2
Utah Railway	111	1
Virginian Railway	562	6
Wabash Railway	2,524	50
Ann Arbor Railroad	294	5
Washington, Idaho & Montana Railway	50	1
Washington Terminal Company	2	1
Waterloo, Cedar Falls & Northern Railway	113	1
Western Maryland Railroad	896	10
Western Pacific Railroad	1,052	4
Wheeling & Lake Erie Railway	537	6
Wichita Union Terminal	....	1
Yosemite Valley Railroad	78	1

Deceased Members

Andrews Allen,
Consulting Engineer

H. F. G. Barnjum,
Designer, Chesapeake & Ohio Railway

F. M. Bisbee,
Retired Chief Engineer, Western Lines, Atchison, Topeka & Santa Fe Railway (Charter Member)

Howard E. Boardman,
Dudley Professor of Engineering, Yale University

G. W. Boschke,
Retired Chief Engineer, Southern Pacific Company

William Bretschneider,
Division Engineer, Southern Pacific Company

M. J. Caples,
Consulting Engineer, New York City

A. Chavez,
Chief Engineer, National Railways of Mexico

A. E. Clift,
President, Central of Georgia Railway

H. B. Dick,
Retired Assistant Valuation Engineer, Baltimore & Ohio Railroad

W. O. Dollarhyde,
Construction Engineer

G. E. Ellis,
Secretary, Committee on Automatic Train Control; Secretary, Joint Committee on Grade Crossing Protection, American Railway Association

H. Fernstrom,
Retired Chief Engineer, Virginian Railway—Charter Member.

F. F. Harrington,
Engineer of Structures, Virginian Railway

Columbus Haile,
Retired President, Missouri-Kansas-Texas Lines

Clive Hastings,
Vice-President, Locomotive Finished Material Company

H. Hawgood,
Consulting Engineer

Eppa Hunton, Jr.,
President, Richmond, Fredericksburg & Potomac Railroad

C. N. Kalk,
Retired Chief Engineer, Wisconsin Central Railroad—Charter Member

William A. Kennon,
Division Engineer, Missouri Pacific Railroad

R. E. Keough,
Western Representative, American Fork & Hoe Company

Dr. C. Herschel Koyl,
Engineer of Water Service, Chicago, Milwaukee, St. Paul & Pacific Railway

W. E. McGraw,
Special Representative of Vice-President, St. Louis-San Francisco Railway

Deceased Members

E. H. McHenry,
Consulting Engineer—Charter Member

J. F. McNally,
Assistant Superintendent, Atchison, Topeka & Santa Fe Railway

J. M. Morrison,
Lease Agent, Central Vermont Railway—Charter Member

William G. Morgan,
Division Engineer, Kansas City Southern Railway; Chief Engineer, Texarkana & Fort Smith Railway

Joseph E. Nelson,
President and Treasurer, Jos. E. Nelson & Sons Company

H. T. Porter,
Retired Chief Engineer, Bessemer & Lake Erie Railroad

W. H. Raleigh,
Roadmaster, Southern Pacific Lines

A. R. Raymer,
Assistant Vice-President and Chief Engineer, Pittsburgh & Lake Erie Railroad—Charter Member

J. S. Robinson,
Retired Division Engineer, Chicago & Northwestern Railway

W. H. Rupp,
Civil Engineer, Oakland, Calif.

W. A. Slater,
Research Professor of Engineering Materials and Director of Fritz Engineering Laboratory, Lehigh University

S. E. Smith,
Assistant Engineer Maintenance, Chicago & Western Indiana Railroad

W. H. Stedje,
Resident Engineer, Minneapolis, St. Paul & Sault Ste. Marie Railway

F. S. Stevens,
Retired Engineer Maintenance of Way, Reading Company—Charter Member

R. M. Stubbs,
Bridge Engineer, Missouri-Kansas-Texas Lines

George F. Swain,
Gordon McKay Professor of Civil Engineering, Emeritus, Harvard University

Robert Trimble,
Retired Assistant Chief Engineer, Pennsylvania Railroad System—Charter Member—Past-President

L. W. Tucker,
Consulting Engineer

J. H. Van Buskirk,
Mechanical Engineer, New York Central Railroad

J. W. Votey,
Professor of Civil Engineering; Dean, College of Engineering, University of Vermont

Samuel T. Wagner,
Consulting Engineer, Reading Company

L. L. Wiggins,
Office and Valuation Engineer, Rutland Railroad

GEOGRAPHICAL DISTRIBUTION OF MEMBERSHIP

United States and Possessions

Alabama	9	New Jersey	48
Arizona	3	New Hampshire	7
Arkansas	28	New Mexico	1
California	69	New York	227
Colorado	15	North Carolina	21
Connecticut	28	North Dakota	3
District of Columbia	35	Ohio	193
Florida	23	Oklahoma	20
Georgia	35	Oregon	9
Hawaii	1	Pennsylvania	195
Idaho	6	Philippine Islands	2
Illinois	350	Porto Rico	1
Indiana	48	Rhode Island	6
Iowa	28	South Dakota	2
Kansas	55	Texas	116
Kentucky	34	Tennessee	22
Louisiana	22	Utah	8
Maine	19	Vermont	7
Maryland	62	Virginia	112
Massachusetts	68	Washington	26
Michigan	60	West Virginia	37
Minnesota	77	Wisconsin	13
Mississippi	13	Wyoming	1
Missouri	220		
Montana	10		2435
Nebraska	40		

Other Countries

Canada	144	Africa	2
Japan	30	Korea	2
Mexico	15	Siam	2
Union Sov. Soc. Rep.	13	Czecho-Slovakia	2
China	11	Bolivia	1
Argentine	10	Costa Rica	1
Brazil	8	France	1
Australia	8	Scotland	1
England	6	Poland	1
Cuba	6	Spanish Honduras	1
Central America	5	Sudan	1
Columbia	3	Switzerland	1
Germany	3	Jamaica	1
India	3	Egypt	1
Manchuria	3		
			286

FINANCES

The financial statement shown in Exhibit A gives in detail the receipts and disbursements, report on the status of the Stresses in Track fund, and General Balance Sheet.

By reference to the statements it will be noted that the Association's financial condition is very satisfactory.

Although the receipts in 1931 were less than those for 1930, the disbursements were also materially reduced.

The principal item in reduced expenditures was for printing the publications of the Association. Committees have collaborated effectively in bringing about this measure of economy and holding down the volume of printed matter to a reasonable basis.

The past year was one in which every business strove for economies. In line with that policy, efforts were made to discover ways for effecting reduced expenditures in Association affairs. Among the measures of economy put into effect and which saved a material amount, was the simple expedient of widening the columns of the Bulletin and Proceedings by one-half inch, thereby increasing the amount of printed matter on each page by 12 per cent, resulting in a corresponding reduction in volume of pages, a saving in postage, etc.

GENERAL

In Retrospect.—Looking back over the record of the past thirty-three years, the Association may reasonably claim that it has amply justified itself. It has kept step with the developments of the railway industry; it has aided in bringing about greater uniformity in methods and practices, and it has properly assumed a leadership in its particular field.

The achievements of the past third of a century are an assurance that the American Railway Engineering Association will continue to exert a potent influence on the proper solution of problems involved in the safe, expeditious and economical handling of traffic on American railways.

Abstracts from Presidential Addresses at annual meetings from 1900 to 1931, inclusive, are made a part of this report. These abstracts are reprinted at this time in the belief that they will be of considerable interest to the members.

Acknowledgment.—The loyal and efficient performance of duty of the office staff during the past year is duly acknowledged.

E. H. Fritch,

Secretary

Exhibit A

FINANCIAL STATEMENT FOR CALENDAR YEAR ENDING DECEMBER 31, 1931

Balance on hand January 1, 1931 ... $51,139.39

RECEIPTS

Membership Account		
Entrance Fees	$ 1,040.00	
Dues	24,066.17	
Binding Proceedings	2,047.50	
Badges	6.50	
Sales of Publications		
Proceedings	1,700.60	
Bulletins	1,567.72	
Manual	2,735.87	
Specifications	1,001.95	
Leaflets	670.31	
Advertising		
Publications	1,727.80	
Interest Account		
Investments	2,248.69	
Bank Balance	94.53	
Miscellaneous	111.89	
American Railway Association		
Rail Investigations	8,952.38	
Total	$47,971.91	

DISBURSEMENTS

Salaries	$ 8,239.92	
Proceedings	2,899.20	
Bulletins	6,019.64	
Manual	87.25	
Stationery and Printing	1,337.39	
Rents, Light, etc.	875.00	
Supplies	98.81	
Expressage	473.16	
Postage	804.11	
Exchange	132.37	
Committee Expenses	104.38	
Officers' Expenses	151.81	
Annual Meeting	984.16	
Refund Dues, etc.	44.95	
Audit	200.00	
Pension (A. K. Shurtleff)	1,200.00	
Miscellaneous	99.49	
American Railway Ass'n.—Rail Investigations	8,888.35	
Total	$32,639.99	
Excess of Receipts over Disbursements		$15,331.92
Balance on hand December 31, 1931		66,471.31

Consisting of

Bonds	$57,411.02
Cash in Central Republic Bank	9,035.29
Petty Cash Fund	25.00
	$66,471.31

STRESSES IN TRACK FUND

Balance on hand January 1, 1931		$ 9,036.45
Received from Interest during 1931		72.66
Total		$ 9,109.11
Paid out on Audited Vouchers during 1931		3,626 50
Balance of fund on hand December 31, 1931		$ 5,482 61

REPORT OF THE TREASURER

Balance on hand January 1, 1931		$51,139.39
Receipts during 1931	$47,971.91	
Paid out on Audited Vouchers, 1931	32,639.99	
Excess of Receipts over Disbursements		15,331.92
Balance on hand December 31, 1931		$66,471.31
Consisting of Bonds at Cost	$57,411.02	
Cash in Central Republic B&T Co	9,035.29	
Petty Cash Fund	25.00	
	$66,471.31	

STRESSES IN TRACK FUND

Balance on hand January 1, 1931		$ 9,036.45
Received from Interest during 1931		72.66
Total		$ 9,109.11
Paid out on Audited Vouchers during 1931		3,626.50
Balance of fund on hand December 31, 1931		$ 5,482.61

The Securities listed above are in a Safety Deposit Box of the Central Republic Bank & Trust Company.

Respectfully submitted,

A. F. Blaess,

Treasurer.

I have made an audit of the accounts of the American Railway Engineering Association for the year ending December 31, 1931, and find them to be in accordance with the foregoing Financial Statements.

Charles Campbell,

Auditor.

GENERAL BALANCE SHEET

December 31, 1931

	1931	1930
Assets		
Due from Members	$ 6,242.50	$ 3,400.92
Due from Sale of Publications	187.85	439.75
Due from Advertising	160.00	310.00
Due from Rail Investigations	753.75	758.88
Furniture and Fixtures	569.00	632.00
Gold Badges	42.50	47.50
Publications on hand (Estimated)	3,000.00	4,000.00
Manual (1929)	3,712.00	5,712.00
General Index	3,269.89	3,269.89
Extensometers	450.00	500.00
Investments (Cost)	57,411.02	40,785.89
Interest on Investments (Accrued)	421.24	257.20
Cash in Central Republic Bank & Trust Co.	9,035.29	10,328.50
Petty Cash Fund	25.00	25.00
Total	$85,280.04	$70,467.12
Liabilities		
Members' Dues paid in advance	$ 5,690.00	$ 6,831.00
Surplus	79,590.04	63,636.12
Total	$85,280.04	$70,467.12

SYNOPSIS OF COMMITTEE REPORTS

Committee on Roadway *(C. W. Baldridge, Chairman).*—The Committee has collaborated with the Railway Bureau of the Portland Cement Association, and prepared revised Specifications for Concrete Fence Posts, as a substitute for the corresponding specifications in the current Manual . . . Consideration of the subject of Roadbed Drainage has been continued, and report is made on Sub-Surface Drainage Pipe Drains. The report deals with definition, soil moisture, soils, and field tests for soils . . . Report is presented on the Influences Affecting the Life of Fence Wire and methods for prolonging the Service Life of Fence Wire . . . The Committee has followed developments in Permanent Roadbed Construction, and describes the installation on the Lehigh Valley's Musconetcong Mountain tunnel section; reference is also made to other installations on various roads . . . Specifications for Overhaul in Grading Contracts and a recommended method for calculating overhaul are submitted . . . The Committee offers as information data on installation and maintenance cost, and data covering life studies of the use of highway crossing planks and substitutes therefor . . . Under the title "Means of Protecting Roadbed and Bridges from Washouts and Floods," the Committee presents an outline of the subject and elaborates on permanent and temporary protection . . . The report on heaving track is offered for approval and insertion in the Manual . . . Specifications for Pipe Line Crossings under Railway Tracks are presented for approval and publication in the Manual.

Committee on Ballast *(A. P. Crosley, Chairman).*—The Committee has continued its study of Specifications for Prepared Gravel Ballast, and during the year has collected information to assist in the formulation of specification clauses to cover such factors as resistance to abrasion and resistance to the action of the weather . . . Some slight modification is proposed in the Specifications for Stone Ballast as a result of the Committee's further study . . . The subject Shrinkage of Ballast has engaged the attention of the Committee for a number of years, and it offers as an interesting item abstracts from testimony presented before the Interstate Commerce Commission on this subject . . . The Committee presents some data on comparative costs of maintaining track on various kinds of ballast . . . The results of a questionnaire on proper depth of ballast are presented.

Committee on Ties *(W. J. Burton, Chairman).*—The Committee has continued its study of the extent of adherence to standard tie specifications, but due to conditions prevailing in 1931, no material change is recorded over those pertaining in 1930 . . . The practice of the Committee in making an annual report on substitute ties installed on various roads has been continued, and a table is presented on tests of substitute ties now in progress . . . Under the heading "Tie Renewal Averages per Mile Maintained," tables are presented giving the 1929 tie renewals reported to the Interstate Commerce Commission, and also those covering the two Canadian railway systems . . . The Committee presents a discussion on the economies of the use of 8½ ft. and 9-ft. ties as compared with 8-ft. ties . . . The results of a questionnaire on methods of dating cross-ties are presented as interesting information.

Committee on Rail *(Earl Stimson, Chairman).*—The Committee offers a revised definition for "Compound Fissure," and a substitute for the present definition of "Horizontal Fissure," to read "Horizontal Split Head" . . . A brief resumé of the work being done on the joint investigation of transverse fissure failures, sponsored by rail manufacturers and railways at the University of Illinois is presented . . . Report is made on the operating results of the A. R. E. A. rail fissure detector car during the past year . . . The usual rail failure statistics for 1930 and for transverse fissure statistics are presented . . . Report is made on tests of alloy and heat-treated carbon

steel rails, including a list of roads using intermediate manganese rail, and failures reported to date of such rail.

Committee on Track *(C. R. Harding, Chairman)*.—A series of revisions in the Track Work plans heretofore adopted are submitted for approval . . . Some minor revisions in the track tool plans are also offered for approval . . . The Committee has had under consideration revision of the Specifications for Steel Tie Plates to provide for shoulder height tolerance, but is deferring final action pending the result of study of the Mechanical Division of revision of its specifications for malleable iron . . . In collaboration with the Standardization Committee of the Manganese Track Society, the Track Committee has prepared a series of plans for switches, frogs, crossings, slip switches, etc., supplementing those heretofore approved . . . Two plans are offered as information, relating to the use of track construction in paved streets . . . The subject of standard wheel flanges, treads and gages has been before the Committee and the Association for a number of years. Conferences have been held with representatives of the Mechanical Division and of the Association of Manufacturers of Chilled Car Wheels. The Committee now presents for approval and insertion in the Manual, a plan entitled "A. R. E. A. Data for Gages and Flangeways through Track at Frogs and Crossings," showing limits where gage is not widened for curvature.

Committee on Buildings *(A. L. Sparks, Chairman)*.—Supplementing the series of Specifications for Buildings for Railway Purposes in the current Manual, the Committee offers tentatively specifications for steel chimneys, brick chimneys, and reinforced concrete chimneys, and, as addendas, draft gages, pyrometer, and lightning protection system . . . Report is made on various types of train sheds, grouped under geographical location; steam and electric operation; passenger terminal on main line, both passenger and freight services; general appearance in harmony with adjoining buildings; cost of construction; cost of maintenance, and probable life of shed. The report also contains tables showing the type and other details of train sheds installed on various roads, and a diagram of clearance comparison covering various roads . . . A discussion of freight house doors, including various types used, such as ordinary wood doors, mill type doors, corrugated sheet metal doors, tin clad doors, steel doors, rolling wood doors, rolling metal doors, overhead wood doors—light construction; overhead doors, heavy construction, wood or metal, vertical lift doors, and continuous doors, is presented in the report . . . An interesting report is offered on sidewalks and station platforms, with illustrations of typical platforms . . . The Committee in 1931 submitted Specifications for Concrete used in Railway Buildings (see Vol. 32, Proceedings, pages 549-556, inclusive), and now recommends their approval and insertion in the Manual.

Committee on Wooden Bridges and Trestles *(H. Austill, Chairman)*.—The Committee reports that due to conditions in the business and lumber industry, no important work in grading rules has been done by the associations of manufacturers of lumber . . . Under the heading "Standardization and Simplification of Store Stock and Disposition of Material Reaching Obsolescence," a series of conclusions and recommendations are presented for approval and insertion in the Manual . . . The Committee presents some interesting illustrations of overhead wooden or combination wooden and steel highway bridges, constructed in Kansas during 1931, substantially in accordance with the typical plans shown in its report of last year.

Committee on Masonry *(Meyer Hirschthal, Chairman)*.—The Committee submits for approval a number of revisions of articles in the Specifications for Portland Cement Concrete, Plain and Reinforced . . . As a continuation of its sudy of the subject of Principles of Design of Reinforced Concrete Arches, the Committee presents a further discussion of concrete arches. The present report covers design . . . An interesting report on progress in the Science and Art of Concrete Manufacture is presented, including a number of illustrations of deteriorating concrete, and views of quarries showing

effect of exposure to alternating freezing and thawing. The report also includes a suggested method of test for soundness of concrete aggregates by sodium sulfate, and a suggested method of test for soundness of concrete aggregates by freezing and thawing . . . The report on Foundations covers procedure to determine the supporting capacity of soils . . . A report of progress is made on prevailing methods and practices of lining and relining tunnels, including a summary of replies received to a questionnaire on the subject . . . An interesting report is presented on the state of the art of repairing deteriorating concrete, and a tentative specification for repairing deteriorating concrete.

Committee on Grade Crossings *(J. G. Brennan, Chairman)*.—The Committee recommends that the present practice of locating whistle post one-quarter mile from the grade crossing be continued. In special cases, where conditions require, distance of whistle post from crossing may be varied, if not in conflict with law . . . It also recommends that the present standard Advance Warning Sign be revised to provide that the letters RR and the cross + be illuminated by means of reflecting buttons . . . Report is made of the various types of grade crossing protection and the various devices are described . . . Forms for recording highway grade crossings; and a record of traffic and delays at grade crossings, railway and highway, are presented for approval and insertion in the Manual . . . A timely report is presented on methods and principles for determining the order in which protection, elimination, and separation of grades at highway grade crossings should be undertaken. Supplementary to the report the Committee presents an interesting paper by John P. Hallihan, a member of the Committee, entitled "The Advantage of Group Participation of Railways in Consideration of Grade Separation Problems in Cities."

Committee on Signals and Interlocking *(P. M. Gault, Chairman)*.—The Committee reports as to developments in Automatic Train Control to the effect that there have been no material changes during the past year . . . On the subject "Increased Efficiency Secured in Railway Operation by Signal Indications in Lieu of Train Order and Timetable Superiorities," the Committee presents the third report of the series, the current report dealing with centralized traffic control, an improved system for railway operation by signal indication . . . To keep the members of this Association informed as to the activities of the Signal Section, A.R.A., a synopsis of the principal current activities of that Section is presented, consisting of a list of investigations and reports; specifications revised; specifications revised and consolidated, and new specifications adopted.

Committee on Records and Accounts *(C. C. Haire, Chairman)*.—The Committee presents a valuable contribution in the form of a bibliography on subjects pertaining to "Records and Accounts" appearing in current periodicals . . . A new subject was assigned during the past year, entitled "Drawings and Drafting Room Practices." A preliminary report is made, consisting of an outline or plan of procedure . . . The Committee offers two forms for approval and publication in the Manual, the first form being an "Annual Report of Highway Grade Crossings;" the second, "Individual Highway Grade Crossing Data," and the third, "Individual Grade Crossing Data (Special)" . . . On the subject of Bridge Inspection Report Forms, the Committee reports progress . . . As information, the Committee offers a discussion of the statistical requirements of Operating, Accounting and other departments with respect to maintenance of way and structures. The Committee submits tentatively a proposed form of monthly report of water station operation. This form is a revision of Form 1301 in the current Manual . . . A comprehensive report on methods and forms for gathering data for keeping up to date the valuation and other records of the property of railways, with respect to (a) changes made necessary by government regulations, and (b) simplicity and practicability of use, is submitted. A series of forms are presented for information . . . The Committee submits a progress re-

port on the assignment of methods and forms for maintaining a record of changes in jointly owned interlocking plants with respect to ownership and contract provisions, including a suggested form for maintaining a record of ownership of joint interlocking plants . . . An interesting report is presented on the subject of methods used in recapture proceedings. A review of the decision in regard to the Richmond, Fredericksburg & Potomac Railroad, on account of the importance of this case, is included in the report . . . Another timely report is made on the subject of methods and forms for handling the I.C.C. requirements under Order No. 15100—depreciation charges of steam railway companies . . . The report includes a discussion of methods for avoiding duplication of effort and for simplifying and coordinating work under the requirements of the I.C.C. with respect to accounting, valuation and depreciation. An interesting chart is made part of the report, showing the organization of the Interstate Commerce Commission and the scope of activities of the various divisions and bureaus.

Committee on Rules and Organization *(E. H. Barnhart)*.—The Committee offers for approval and printing in the Manual, "Instructions for the Guidance of Engineering Field Parties" . . . A revision of the material heretofore adopted is presented relating to "Titles of rank of Division Engineer and below, to designate positions of corresponding rank in maintenance of way service" . . . Additional rules for insertion in the "Manual of Rules for the Guidance of Employees of the Maintenance of Way and Structures Department" are presented for approval. The supplementary rules cover: rules for Maintenance of Bridges—Steel Structures; rules for the Maintenance of Bridges—Masonry; rules for the Maintenance of Other Terminal Structures . . . Report is also made on the subject of titles employed to designate positions of corresponding rank in maintenance of way service, subordinate to that of Division Engineer, and titles for positions now assigned to Assistant Engineers in departments other than maintenance of way . . . A series of rules for fire prevention as applying to the Maintenance of Way Department are submitted for approval.

Committee on Water Service and Sanitation *(R. C. Bardwell, Chairman)*.—The Committee presents a revision of the Standard Methods of Water Analysis and Interpretation of Results, and also submits definitions of the terms "Grooving," "Pitting," and "Embrittlement." Specifications for Salt to be used in Regeneration of Zeolite Water Softening Plants are submitted for approval and insertion in the Manual . . . In the absence of important developments in the theoretical aspects of pitting and corrosion of locomotive boiler tubes and sheets, the Committee has confined its activities during the year to summarizing results of practical service tests of various methods of prevention which have been tried out during the past five years . . . The Sub-Committee on Methods and Value of Water Treatment, of which the late Dr. C. H. Koyl was Chairman, presents an interesting and valuable contribution, supplemented by a number of illustrations . . . A final report is made on Washouts, Water Changes and Blow-downs of Locomotive Boilers, with conclusions . . . A final report is also made on the Application and Comparative Economy and Effectiveness of Various Coagulants . . . Still another final report is presented on the Advisability of Standardizing Valves and Packing for Water Service Pumps . . . The Committee includes in its report a tribute to the late Dr. Koyl in the form of a resolution.

Committee on Yards and Terminals *(H. L. Ripley, Chairman)*.—Important revisions in the chapter on Yards and Terminals in the current Manual are presented, consisting of additions to the data on Freight Yards. Under Hump Yards, a series of clauses are submitted, including Hump Yards with Car Riders and with Car Retarders . . . A valuable report on Produce Terminals is offered as information, illustrated with typical layouts . . . The Committee has continued its study of parking and garage facilities for private automobiles of railway passengers at passenger terminals and way stations, and presents typical cooperative layouts for auto parking space

units . . . The Sub-Committee on Hump Yards presents a comprehensive and valuable report on this subject, including formulae for use in designing retarder hump yard gradients from the crest of the hump to the lower end of the classification yard. A diagram of a typical head end layout of a retarder operated classification yard is included in the report . . . Progress is reported on coordination of rail and water terminals. The Committee has collected a mass of information, a synopsis being on file in the Secretary's office, and may be consulted by anyone interested in the subject . . . One of the outstanding assignments to this Committee is the subject of Scales for Railway Service. As a result of cooperative action of interested organizations, Specifications for Railway Track Scale Test Weight Cars are submitted as information. Under the direction of Prof. W. M. Wilson, a member of the Committee, an investigation has been made at the University of Illinois Engineering Experiment Station, of the bearing value of scale pivots. The complete report of this study is to appear in a Bulletin of the Engineering Experiment Station . . . Continuing its former practice, the Committee presents an interesting bibliography of articles appearing in current periodicals, relating to passenger stations and terminals; freight stations and terminals; rail-and-water terminals; airports and rail-air transportation.

Committee on Iron and Steel Structures *(A. R. Wilson, Chairman)*.—Under the direction of the Committee, the fourth edition of the General Specifications for Steel Railway Bridges was issued under date of May, 1931. There has been a very gratifying demand for this publication from railway companies, bridge companies, steel companies, and from colleges for use as a textbook . . . The Committee has followed developments in the use of copper-bearing steel for structural purposes, and submits for approval and publication in the Manual, its conclusion that "from results of exposure and service tests on the use of copper-bearing steel, its value is recognized as a rust-resisting metal, and its use is recommended in railway structures exposed to corrosive influences."

Committee on Electricity *(Sidney Withington, Chairman)*.—To avoid duplication, the report of this Committee consists of a synopsis of reports submitted to the Electrical Section in the fall of 1931. The subjects to which reference is made in the report are: Inductive Co-Ordination, Power Supply, Electrolysis, Cooperation in Miscellaneous Regulations, Overhead Transmission Line and Catenary Construction, Standardization of Insulators and Insulating Tape, Protection of Oil Sidings from Danger Due to Stray Currents, Specifications for Track and Third-Rail Bonds, Illumination, Design of Indoor and Outdoor Substations, High Tension Cables, and Application of Corrosion-Resisting Materials to Railroad Electrical Construction.

Committee on Uniform General Contract Forms *(F. L. Nicholson, Chairman)*.—In collaboration with the Electrical Section, a Form of Agreement for the Purchase of Electrical Energy in Large Volume (such as required for traction purposes) has been formulated and is offered for criticism and suggestion . . . The Committee also presents for approval a Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project, prepared in cooperation with the Committee on Yards and Terminals. The form is in two parts—Organization Agreement and Operating Agreement . . . A report is made on the subject of Form of Conveyance of Title Granting the Right to Construct and Maintain Air-Right Buildings over Railway Property. At the present time, the use of air-rights is limited to a few of the larger cities, but the prospects are that the number of air-right conveyances will increase materially in the future . . . The Committee has under consideration the preparations of a Form of Agreement for Pipe Line Crossings under Railway Tracks.

Committee on Economics of Railway Operation *(J. E. Teal, Chairman).*—Studies have been undertaken by the Committee to test out the theory of train-hour diagrams and to obtain experimental knowledge that will serve to extend the scope of the method in connection with the investigation of factors affecting freight train operation. These studies indicate that comparative freight train performance charts provide a simple and accurate method for showing actual results obtained by various methods of operation or changes in facilities, and conclusions have been drawn from the studies which are offered for approval and publication in the Manual . . . An interesting report is made on the subject of converting double track into single track, and the result of a study on the effect of removing 24.6 miles of track on a 62.5-mile section of road where traffic has been reduced from a total of 30 trains—freight and passenger—per day in 1920, to 12.6 trains—freight and passenger—per day in 1930 . . . During the past year, the Committee has given attention to a preliminary study of problems of operation as affected by curvature and rise and fall, and reports progress on the assignment . . . The Committee also reports progress on the subject of most economical makeup of track to carry various traffic densities, and on the effect of traffic density on operating expenses.

Committee on Economics of Railway Labor *(F. M. Thomson, Chairman).*—Under its assignment "Analysis of Operation of Railways that have made marked progress in Reduction of Labor required in Maintenance of Way Work," the Committee has made a survey of the Lehigh Valley's maintenance of way operations and presents some interesting data . . . The Committee submits a further report on the effects of recent developments in maintenance of way practices of gang organization (such as use of heavier rail, treated ties, and labor-saving devices, which make practicable small section forces, and conducting the major part of maintenance work with extra gangs), and presents the result of a special study of practices now in effect on several selected railways . . . An interesting report is submitted on the practice of a various railways on "Annual Track Inspection and Prize Awards" . . . The Committee presents an informative report on the relative economies of brush versus spray painting and offers for approval and insertion in the Manual, a series of conclusions on the subject.

Committee on Shops and Locomotive Terminals *(L. P. Kimball, Chairman).*—Under the headings "Engine House Design," and "Storehouses for Shops and Locomotive Terminals," the Committee offers for approval a number of changes . . . A comprehensive and valuable report is presented on general layouts and designs of typical locomotive repair shops, including a time study of machine tool operations for locomotive repair shop, illustrating the practices of the Huntington (W. Va.) shops of the Chesapeake & Ohio Railway, and a tabular statement of the estimated forces to operate this particular shop. The report also includes several exhibits showing the layout of the Huntington shop . . . The Committee also submits two reports on adapting the general layouts and design of car shops for inspecting and repairing multiple unit electric cars, and adapting the design of engine houses and general layouts and design of typical locomotive repair shops for the inspection and repair of electric locomotives, the latter illustrating the general features of an existing engine house and shop, adapted to provide for electric power . . . An interesting and timely report is submitted by the Committee on the modernization of engine terminals to eliminate use of steam power plants for other than heating plants . . . Recommendations are presented on the design of inspection pit, and are offered for approval and insertion in the Manual . . . Supplementing previous reports, the Committee presents a report on engine terminal layouts, grouped under the headings of (a) steam locomotives, and (b) electric locomotives. The report includes a diagram of a proposed shop and terminal for electric locomotives, and layouts of electric locomotive terminals of the New York Central and the Cleveland Union Terminal Company.

Committee on Rivers and Harbors *(E. A. Hadley, Chairman)*.—The Committee again presents definitions of terms pertinent to its subject but desires to give them further study before recommending their approval . . . The Committee submits a discussion on the types of construction for levees, dikes and mattresses for use under varying service conditions, and offers for approval a series of specifications for the construction of the several types of river bank protection in common use, including specifications for woven willow mattress; for pole, brush and rock dikes; for pole and brush bank mattresses; and for brush fascines . . . Different types of bulkheads, jetties and seawalls are described and illustrated, together with a statement of the purpose they serve, first cost, service life and maintenance cost of the various types . . . The different types of fender systems for protecting wharves are described and illustrated, and also comparisons of first cost, service life and maintenance cost of the various types . . . An interesting report is presented on the types of warehouse piers, coal and ore piers, etc., including data on comparative cost and advantages of the different types . . . The size and depth of slips required for economical operation of the various types of wharves and traffic conditions are reported on.

Committee on Standardization *(J. C. Irwin, Chairman)*.—In the introductory to its report, the Committee points out the importance and value of simplified practice and standardization . . . Examples are cited of economies brought about in industry by simplified practice by the elimination of unnecessary or uneconomical types, sizes and grades of material . . . Participation by railways in the work of the American Standards Association is outlined . . . The railway personnel of the Canadian Engineering Standards Association is listed . . . An interesting paper, contributed by Edwin W. Ely, Chief, Division of Simplified Practice, U. S. Bureau of Standards, entitled "Simplification in the Railway Field," is included in the report . . . A list of standards approved by the American Standards Association, for the period September 1, 1930, to September 1, 1931, and a list of technical projects under American Standards Association procedure, on which A.R.E.A. members are cooperating, accompany the report.

Committee on Maintenance of Way Work Equipment *(C. R. Knowles, Chairman)*.—Recommended practice relating to standardization of parts and accessories for railway maintenance motor cars is offered for approval . . . The use and adaptability of dragline equipment with caterpillar traction in maintenance of way work is reported on, and includes general description, class of work for which adapted, method and cost of operation, repairs and depreciation, and desirable features . . . A comprehensive report is made on the use and maintenance of paint spraying equipment, with an outline of typical organizations for various classes of work . . . An interesting and valuable report is presented on the organization for the use and maintenance of ballast cleaning machines and the conditions under which each particular type may be used. The report also contains illustrations of ditcher ballast cleaner, center ditch mole, and special ballast cleaning machine . . . The Committee also reports on the use of oil spraying machines for oiling rails and fastenings, steel structures and roadbed, and presents some interesting information.

Committee on Waterproofing Railway Structures *(J. A. Lahmer, Chairman)*.—This Special Committee was created during the past year, and its first report is one of progress . . . A series of definitions of terms are offered for approval . . . When to waterproof or dampproof and methods to be used, and waterproofing and dampproofing as applied to existing railway structures will be reported on in subsequent reports.

Committee on Stresses in Railroad Track *(Dr. A. N. Talbot, Chairman).*—In its progress report, the Committee outlines the nature of the experimental work conducted on the track of the Chesapeake & Ohio Railway near Ashland, Ky., and on the installation of the GEO track of the Missouri Pacific Railroad near Middlebrook, Mo. . . . The Committee calls attention to a paper on "Rail Stresses and Locomotive Tracking Characteristics Found in Tests on the Great Northern Railway," published in Bulletin 339 (September, 1931).

Committee on Clearances *(A. R. Wilson, Chairman).*—Supplementing the series of clearance diagrams heretofore presented, the Committee in its current report submits for approval clearance diagrams for high and low platforms.

ABSTRACTS FROM PRESIDENTIAL ADDRESSES AT ANNUAL MEETINGS, 1900–1931 INCLUSIVE

*John F. Wallace—1900

While the question of what is economical management respecting maintenance of way and structures is one which the management of each property must solve for itself, we can certainly assist each other by a full and frank comparison of views and a discussion of the various elements that constitute an economical handling of our maintenance of way work. The establishment of certain recognized principles as the result of our investigations and discussions will materially assist our managements in adopting a policy that will lead to the truest and highest economy.

*John F. Wallace—1901

In these remarks attention has only been called to the fundamental principles and the general lines along which this important subject of economical railroad maintenance should be approached. Above all things, we should give consideration to the proper relation of things, and not fall into the error which many Engineers make of looking at this question from a technical standpoint only, and endeavor to rear the most substantial and perfect monuments to their own skill—building structures to which they can point with pride as samples of their work, and losing sight of the fact that the ultimate aim of railway construction and maintenance is to provide for the safe, expeditious, and economical handling of traffic. To this end all other considerations are subordinate.

George W. Kittredge—1902

It is encouraging to feel that the high executives of the railways look with favor upon our organization, and with interest upon our meetings, discussions and publications. The year 1901 has been a very busy year with most of us, and it is during busy years that the work of the Association should be of most value. We have with us men who stand high in our profession, who have had most valuable experience in all kinds and grades of work. Through our meetings, discussions and publications, opportunities such as were never before offered are given for the dissemination of knowledge pertaining to our particular branches, and of the results of carefully studied and worked-out methods. Our publications should become the textbooks for maintenance-of-way work, and should be kept easy of access to those who strive to know what is considered good practice, and endeavor to conduct their business upon intelligent, systematic and economical lines.

We can safely predict an increasing appreciation as our work becomes farther advanced, and as the reports of our committees become complete in recommendations, and the Association puts its stamp of approval upon them.

George W. Kittredge—1903

The question of committee reports has been the one most engrossing topic of consideration, and we are glad to present to you at this convention reports which have been formulated upon general lines as to form and manner of treatment, which justify the methods prescribed. The reports presented at this convention are the best that have been presented at any of our conventions, and are worthy of places in what will become the textbooks of our calling.

The issuing of Bulletins at stated intervals has been inaugurated, and as the reports contained therein are read and digested by our members, the Association will derive benefit from a more free and general discussion of them, and will be better able to put its stamp of approval upon the recommendations contained therein.

Hunter McDonald—1904

The prime reason for our organized existence is the opportunity offered for interchange of views on matters in which we are interested and the benefits to ourselves and employers to be derived therefrom. Such interchange of views should not be confined to a few members who may perhaps be moved to speak or write, not from a profound knowledge of the subject, but because those who are better qualified to enlighten us remain silent. It is earnestly hoped that members will express themselves freely on all subjects in which they feel an interest, and those whose experience gives weight to their words will not

* Deceased.

wait for an invitation to speak out. It is very gratifying to the committees to have their reports bring out full and interesting discussion, and disappointing to them if they fail to produce this result. As a general proposition, everybody loves a good listener, but if we all remain listeners, there will be none to love us.

Hunter McDonald—1905

It has been our practice in the past to shun all discussion of devices and appliances which are proprietary articles or covered by patents. The reason for such a course seems to be the fear of advertising such devices. When it is remembered that nearly all the important improvements in railway appliances of recent years have been the result of the labors of men not connected directly with railroads and that many patented and proprietary appliances are indispensable articles of daily use, it would seem that our position in this matter is incorrect. If the objects of our organization are to be attained we should not hesitate to ferret out and condemn the unworthy and to commend the meritorious. By such a course the real advertisement would be confined to those worthy of receiving it. It is fully realized that such a course is strewn with pitfalls, but we possess the intelligence and integrity to avoid them.

*Howard G. Kelley—1906

In the general discussion of the subject-matter of committee reports, the Chair desires to urge upon the members a free expression of their opinions, either for or against the various particular items contained therein, for it is only by such free and open interchange of thought that the sum of our knowledge be increased and the underlying principles of a subject be differentiated from local or particular conditions.

Some apparently conflicting specifications are in reality the adaptation of a general principle to meet conditions existing in particular localities. The economic construction grade line for a railroad in a southern state would not necessarily be the correct one for a railroad in 50 degrees north latitude, and as our Association now contains members from all quarters of the world, a general and free recital of experience will add materially to the wealth of knowledge contained in our publications.

When it is considered that to the members of the Association is entrusted the expenditure of millions of dollars capital annually, and the maintenance of the permanent way by which the transportation of persons and property may be handled with safety and economy, the responsibility resting upon us as an Association and as individuals may be realized.

*Howard G. Kelley—1907

The Committee reports show an increased excellence of arrangement and digest of facts, and the adoption of clear, concise specifications is reducing to a common standard the varying practice of the members and of others not members who are engaged in construction work. The fact that the specifications already adopted by the Association and published with the seal of its approval are looked upon as authoritative standards, emphasizes the necessity that our proceedings should be marked with care and receive the most thoughtful consideration; and no final action of the Association should be taken until every feature of the subject under consideration has been determined.

*A. W. Johnston—1908

Standing on the threshold of the tenth year of its existence, your Association, in taking stock of its achievements, must contemplate with much satisfaction and with pardonable pride the record of its progress from year to year, and, looking backward to its inception, and then considering the unprecedented advance in all departments of industrial science, synonymous with the extraordinary development of the material resources of our Nation, and of the whole world, it would almost seem as if the little group of men, the founders of this organization, were gifted with precognition as to its need and future. In no other era, perhaps, has there been so great a demand for the rightful application of exact knowledge, and the mission of this Association has been to encourage that form of investigation which tends to exactness in acquiring knowledge, and sound judgment in its application to the practical problems confronting us.

*Walter G. Berg—1908

I wish to add one thought, and that is as to the value of our Manual. I might say in a certain sense that the Manual is the overt act through which we indicate to the profession at large and the railway authorities what we have accomplished, what we have considered worthy to present as recom-

* Deceased.

mended practice. Therefore, in a certain sense, we should concentrate all our efforts in improving that Manual, not only by additions considered and adopted in proper form, and being included in the Manual, but by keeping the Manual up to date by differentiating and excluding all matter previously adopted, not in harmony with subsequent action, or obsolete, as it may well be understood that matter adopted five or six years after the original matter was adopted would allow us to reasonably infer that some matter adopted earlier is obsolete, due to the advancement and trend of the art in the interim.

*William McNab—1909

The bibliography of your Association is, in consequence, liberally made use of to advantage, not only by the members, but by the executive officers of our railways, as being practically authoritative on railway technical details. In this general connection, we are amply justified in stating that there need be no hesitancy in accepting as good modern practice, based upon scientific methods, the general principles which are recommended therein. You are all aware that before any of the various recommendations are adopted and disseminated, they have been thoroughly discussed and voted upon in open convention by the most competent and up to date body of railway Engineers to be found anywhere, and in no other organization is there a greater degree of care exercised to guard against inconsistencies than is exhibited in our own. But while there is every reason to be proud of our achievements during the past ten years, we should not rest content, but endeavor to keep our work up to date by eliminating from our recommended practice what in course of time has become obsolete and perfecting that which is considered worthy of retention, in order that our recommendations may be safely relied upon as representing the best practice that can be devised for the time being.

*William McNab—1910

It is not the purpose of this address to consider the reasons why the percentage of mileage added during the year was not greater, for it may be said that beyond having an interest of a general nature, such as may be accepted as universally shared in, it seldom comes within the special purview of the railway Engineer to study in detail economic laws which govern eras of commercial prosperity. Neither does it directly belong to his province to question the attitude of the Federal or state legislatures toward railway interests, or to analyze the complex factors which frequently produce the conditions leading to business stagnation or financial crises.

To the Engineer in such matters the prime feature of import for the time being is trade and economic conditions as they exist, and it is in the degree in which such conditions are active that becomes the potential in his everyday life and avocation. From an Engineer's standpoint, it is more desirable to anticipate the future and to consider and plan what has yet to be done, rather than to view the present situation in the light of what has not been accomplished. This statement, however, by no means implies that retrospect of work that has actually been done is unprofitable, for the members of an Association such as this can well afford to review the records of construction of some portions of lines built during the year. In the official descriptions of such construction it is clearly indicated that many novel and interesting engineering problems presented themselves for solution, and the progressive methods used in every branch of work show that system, as applied to railway operation, has made a substantial advance and become more highly developed than in any other of the industrial arts.

L. C. Fritch—1911

The railway industry is being circumscribed by governmental regulations to the extent that its operations, to the minutest details, are being regulated by law or prescribed by rules of commissions created under Federal or state authority. Some of these regulations are wise and beneficial, and were necessary to purge the railway business of its past sins of omission and commission. However, many of the regulations, conceived by irresponsible persons and for sinister purposes, are a positive menace to the public they were designed to benefit; these will serve no good purpose, but prove a positive check to railway development. In this feature we are vitally interested, and it devolves upon us as citizens, true to our calling, to educate the public to a realization of the rights and the justice that is due the railway industry.

It has been asserted that railways are extravagant and wasteful in their methods of operation and lack system in conducting their business. These charges are not in accordance with the facts as we know them. Organizations similar to our own are giving their best thought to the improvement of methods and to the promotion of efficiency in all departments of railways.

We have an abiding faith in the fairness and common-sense of the American people, and are confident that our incomparable country will progress with undiminished momentum. New lines of railways will continue to be built, existing lines will be revised and rebuilt—and herein lies our duty.

* Deceased.

W. C. Cushing—1912

The year 1911 has witnessed the continued progress, and in some cases the completion of vast works of Engineers, governments, whether Federal, state or municipal, continue their works in times of depressed business as well as in prosperous times, and, therefore, the three greatest government undertakings, the Panama Canal, the Catskill Aqueduct and the Erie Canal, have been pushed steadily forward.

. . . Another important government enterprise, which was brought to successful completion last March, is the Roosevelt Dam, in the canyon of the Salt River, about 70 miles east of Phoenix, Arizona, as it is the purpose of impounding 418,000,000,000 gallons of water for irrigation. It is 276 feet high, with a crest length of 1,080 feet. It was begun in September, 1906, and was estimated to cost about $3,850,000 . . .

Notwithstanding the depression in business, the year witnessed the continued progress, and also the completion, of some magnificent engineering works in the railway world.

The erection of the enormous and palatial station of the New York Central Lines in New York City has been finally started, after carrying on since 1903 a large amount of preliminary work of excavation, track laying and office building . . .

On June 4, 1911, the large new passenger station of the Chicago & Northwestern Railway in Chicago, costing about $24,000,000, was opened for service . . .

Another great railroad enterprise, estimated to cost $9,500,000, is the line and grade improvement of the Delaware, Lackawanna & Western Railroad. between Slateford, Pa., and Hopatcong, N. J., which was opened for traffic Christmas, 1911 . . .

Last April it was announced that a beginning has been made on the last of the $160,000,000 worth of improvements started in 1903 by the Pennsylvania Railroad Company, viz., the New York Connecting Railroad, which will link the Pennsylvania and New Haven roads together. This link will be 12 miles long, the principal feature of which will be the four-track bridge from Astoria on Long Island over Hell Gate, Ward's and Randall's Islands to Mott Haven or Port Morris. The bridge over Hell Gate and its approaches will be about 3 miles long, and will be of most massive construction, costing about $20,000,000 . . .

Chas. S. Churchill—1913

With the completion of another year in the existence of the American Railway Engineering Association, it is well to review its accomplishments and to point out the work before it.

Its first notable accomplishment has been: The standardization of materials, designs, specifications and records used in the construction and maintenance of the various parts of a railway.

Second—Progress has been made in the specifications governing the making of such complex materials (so largely used by railways) as concrete and steel.

While the first of these items relates almost wholly to materials, the proper use of these materials is largely dependent upon labor, skilfully and economically directed; and the second item—namely, the manufacture of such materials as concrete and steel, is very greatly dependent upon the quality of the labor and upon the honest and thorough use of it.

Edwin F. Wendt—1914

The American Railway Engineering Association continues to grow in membership and usefulness. The past year, 1913, has been characterized by the loyal devotion and conscientious work of members, committees and the Board of Direction.

Conservatism prevails at all times in the conduct of the affairs of the Association.

The committees are endeavoring primarily to accomplish work of quality without reference to its quantity. The membership is awake to the situation, and is working to increase our members and influence.

Fifteen years have passed since the organization of our Association. The men who gathered at the first convention, held in Steinway Hall, Chicago, on March 14, 1900, probably had a vision of the future; but the success of our efforts has exceeded even the fondest hopes of those who organized the Association. They certainly heard a voice, saying: "It doth not yet appear what we shall be." And we hear the same voice today, but the question now is, not one of success, but how strong and useful may the Association become.

W. B. Storey—1915

Financial conditions have very seriously affected all railway and engineering construction during the past year, and as a consequence there is lacking the usual long list of notable achievements. One event stands out prominently, viz., the opening of the Panama Canal, which is so directly allied to our character of endeavor. This has interested us in the past as an engineering work, and the methods and details of construction have been followed with absorbing interest. The opening of the Canal is now introducing economic features in the country's transportation problem which may have a far-reaching effect, possibly changing a large element of the transportation of the country from rail to shipping, and, incidentally, raising questions of economical handling of freight at docks and wharves, and the attention of our members interested in this class of work is called to this fact. At the present time the overland roads are feeling seriously the inroads on the business formerly carried by them, and as the shipping interests are enlarged the subject may be even of greater importance.

*Robert Trimble—1916

Work on the new Union Station in Chicago has begun. The railroads are being criticized for their extravagant passenger terminals, and this one is no exception. A visitor from Australia recently speaking in Chicago commented on our extravagant terminals, especially the "gilt stairways and marble halls," and his tale has been taken up by prominent newspapers and magazines all over the country. A great lack of knowledge is shown by the critics in regard to the amount of money being spent for the beautification of a large railway terminal.

Take the new Chicago Union Station as an example, estimated to cost, in round numbers, fifty million dollars. Nearly thirty-five millions represents land. The figure cannot possibly change, no matter what kind of structures are placed upon it, unless a location in the heart of the city, which is the place where the traveling public wants to land, is abandoned or smaller facilities accepted. About five millions are for changing streets, rebuilding viaducts and bridges and reconstructing public utilities, and this cannot be escaped because the necessary enlargement of the station to take care of a growing business requires the reconstruction of these bridges and streets. About five millions are for tracks, signals, interlockings, platforms, train sheds, power plant and necessary appurtenances of the station. This leaves five million dollars for the headhouse and concourse, the only part of the station where there can be any real question as to extravagance.

If a strictly utilitarian headhouse and concourse, the part that the public thinks of as the station, were to be constructed, the total cost might be reduced two million dollars. This figure represents what the railroad companies are paying for an advertisement, for the comfort and pleasure of its patrons, and the beautification of the city . . .

*A. S. Baldwin—1917

Considering it advisable to determine the extent to which recommendations in the Manual as to specifications and standards are being made use of, a circular letter was addressed to heads of engineering departments of the railroads represented in your Association. The replies were gratifying, many of the department heads going into the use made of the Manual in great detail.

From an analysis of the replies it is shown that the standards and specifications are exerting a very powerful influence toward a general unification of practice. Many of the recommendations of the Manual are being adopted literally, others with changes to suit local conditions or individual ideas, and to a very great extent they are being used as an aid and guide.

It is of great importance that the chairmen of committees should fully realize their responsibility for the maintenance of a high standard for the material going into the Manual. It embodies in a small scope, but to a great extent, the net results of the labors of the Association, and should be carefully guarded.

If every member of your Association would, when the time comes to prepare standards, consult the Manual and exhibit a willingness to relinquish, wherever practicable, pet ideas and theories for the great benefits to be attained by a unification of practice, the economies that would accrue to the railroads of the country are almost inestimable.

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* Deceased.

John G. Sullivan—1918

In conclusion, let me impress on your mind the necessity of taking an active interest in public affairs, not alone in going to the polls and voting for the least objectionable officeseeker, but by taking an active interest in the selection of the candidates and, if necessary, sacrifice time and other interests to become yourselves public officials, if called upon to do so, remembering that when this war is over the responsibility placed on the voters of democracies will be greatly increased and especially so in the United States, where you have gone one step farther than democratic Canada and other less radical democracies, by the fact that you not only elect your legislative bodies, but you also elect by popular vote your judiciary and executive officers. And realize further, that you need honest, intelligent and capable representatives more in times of prosperity than you do in times of adversity. In the meantime, let us all join hands with the government, put our shoulders to the wheel, and do all in our power to win this war for freedom and democracy, and after victory, let us then not shirk our duty, but assume the responsibility of self-government, making sacrifices where necessary and thereby making democracy a real success.

C. A. Morse—1919

The events of the past four years have been the means of introducing the Engineer to the world at large, and it has discovered that, instead of being some kind of a scientific specialist, required occasionally but called upon as seldom as possible, that he is a person with real red blood, and then when Uncle Sam got into trouble, he called upon the Engineers, and lots of them, to not only start the work for him, but to furnish the sinews of war, and the skill to use those sinews, with the result that the Engineer today needs no introduction; the world knows him, and he will take his proper place in the world's work. He has come out of his shell, and is in the limelight, and if he does not stay there, it is his own fault.

The events of the past four years have brought about another change that will be far-reaching, and will affect the Engineer and his work. The gathering together of nearly four million soldiers from all stations in life, and the fact that when these men were put in uniform and trained for soldiers, it was not a question of education, family connections, or financial conditions that counted, but the *man*, and when it was shown that there were equally good men measured by courage and manliness developed from one class as another, it opened the eyes of all to the fact that, measured by the standard of red blood and physical ability, class disappeared, with the result that they will all return with greater respect for mankind.

Earl Stimson—1920

The shunning of railroad service by the young Engineer is a matter of concern. I noticed a short time ago in a technical publication a series of letters written by the Professors of Engineering of a number of Universities, on why the graduate Engineer is not entering railroad service. The chief reason given was that they found more attractive service elsewhere—the more attractive features being better pay, less exacting working conditions and better prospects of advancement. I cannot believe this to be a permanent or even a general condition.

The railroad offers today splendid chances for any bright, hustling young Engineer graduate, either up through the Engineering and Maintenance Department or through the Transportation Department. The work is exacting and the hours at times long, but he has only to look at the long list of prominent railroad officers who started on the engineering corps and attained to positions comparable in compensation (which it would appear to be the measure) to the high positions in the industrials, to see rewards that may be his.

Your Association is dependent upon the young railway Engineer for its perpetuation. It is therefore the mission of the members of this Association to present to the young Engineer the advantages and possibilities of railroad service, and when he has entered that service to help him in every possible way toward the realization of those possibilities.

H. R. Safford—1921

This annual meeting marks the close of the twenty-second year of the life of the American Railway Engineering Association—practically a generation as human life is measured.

And, in some ways, it would seem that we have just passed through a period which will mark a very definite generation in the history of railroads.

This thought is suggested when we recall that at the end of the Association's twenty-first year we find the railroad industry, of which we are a part, at the threshold of a new era.

Many things point to this belief, marked primarily by a new Transportation Act expressing a desire on the part of the public for private control with protective regulation, with expressed support

of efficient and honest management and an earnest desire to restore confidence in the enterprise and credit to the structure.

The termination of Federal control and the restoration of the properties to their owners coincident with the passage of the new Transportation Act seem to mark the close of a period when there was a noticeable and increasing tendency toward excessive and burdensome regulation, an increasing failure upon the part of the public to fully understand and appreciate the rail transportation structure and especially a failure to realize the interdependence and joint responsibility resting upon both the railroad and the user to create, support and maintain what the public most desires, namely, good transportation.

These tendencies were the natural result of influences not of a constructive character and preaching discontent, unfairness, and discrimination, appealing to the individual or the territorial group of the public and shipper who naturally felt interested from a viewpoint of limited scope and dominated by selfishness rather than a desire to assume any responsibility for maintaining an efficient public service in general.

A great change, and, I believe, for the better has taken place—new powers and responsibilities are assumed by lawfully created public bodies—a different attitude is observed on the part of the shipper and the traveller and new conditions also surround the details of operation affecting theories of development and expansion of existing properties and the promotion of new projects, which are vastly different from twenty-one years ago.

L. A. Downs—1922

The real test of the good work the Association is doing is whether our recommendations are being put into practice on the railways. The executive head of every railway having members in the Association or not should put it up to the head of the Engineering Department as to whether the recommendations of the American Railway Engineering Association are being made use of in that Department, and if not, to give reasons for not doing so. The answers to that question will be constructive criticism, and our Association will know its destiny from such reports.

J. L. Campbell—1923

Until the Committee on Economics of Railway Labor was created, the work of the American Railway Engineering Association was directed only to the solution of the problems of railway construction, maintenance and operation of the physical property of the railways. The economics of labor covers more than that, and includes the welfare of labor.

Railway Engineers are masters in solving the physical problems of transportation. They have done very well indeed in that. But the most difficult problem of the transportation or any other business is not physical. The really formidable problem is the man behind the gun—the human equation. If mind and heart were amenable to the principles and rules of physical science as they are applied in solution of physical problems, the Engineering Department would be the department in which the problem of the human factor could be solved. But it is not so. The human equation, overshadowing every other in all the relations of life, requires for its solution (and it must be solved) a department of religion. Its solution will be found in the teachings of Jesus Christ equally assimilated and jointly practiced by employer and employee. There is no hope in the rule of might uncontrolled by right. "The fear of God is the beginning of wisdom," and the secure foundation for industrial association and activity.

While no department of a railway is fashioned primarily for the purpose of solving the human problem, railway Engineers are, by training and necessary familiarity with and loyalty to that part of truth found in the principles and facts of nature involved in the science and art of controlling and directing the physical forces of nature to the use and convenience of man, qualified to become proficient in the higher science and art of directing the spiritual forces in nature to the end that there shall be more fully established among men and between employer and employee right relations and purposes. In this higher kingdom wherein lie the destinies of men and nations and the keys to the solution of the problems of life and society, the members of the American Railway Engineering Association have individually opportunity for service of fundamental value to the transportation business and to society. As I look upon the part of that membership massed in this hall today, I am impressed by its potential power for right leadership.

E. H. Lee—1924

Our Association is undoubtedly coming to be the recognized authority upon questions of construction and maintenance, and upon some questions of operation. It will continue to deal with the specific activities it was organized to handle, and as I believe with the continually increasing prestige that comes from needed work well done. I think its members are also to do their share toward the solution of these grave problems of human contact and relationship, both because they have their share of brains and initiative freely available for the needs of the companies they serve, and because they well appreciate that the thoughtful study of these problems is a good preparation for the duties of the higher positions toward which many of them are advancing. If I may hand on a word of advice to our younger members, so full of brains and ambition and enthusiasm, I would be inclined to say as everyday work, do the job in hand to the best of your ability; as special work, master railroad accounting in principle and practice; and as a general interest, study the psychology of your fellow-men—a large order, perhaps, but upon your knowledge of and the usefulness of your mutual relations with those associated with you, both above and below, rests any success in official positions or in efficient teamwork in any possible capacity.

This is the hour of our twenty-fifth attack upon the forces of ignorance, prejudice, unfairness, inefficiency and narrow self-sufficiency—LET'S GO!

G. J. Ray—1925

At the present time the railroads of the country are passing through one of the most interesting stages of their existence. During the past year we have seen some of the first moves towards consolidation under the Transportation Act of 1920. It may be asked: yes, but what has the American Railway Engineering Association to do with railroad consolidation? Not much, to be sure. Nevertheless, one of the important requirements of the law of 1920 is that the roads must be economically maintained and operated. After the financiers, the attorneys and the Interstate Commerce Commission have gotten through with the various consolidation schemes, the new freight rates set up and the public and stockholders have become accustomed to the new order of things, our job will start.

As construction engineers and maintenance officials we will have to help build up some of these new combinations to a point where they are capable of handling the business and to maintain them in an economical manner and safe condition. We will be called upon to adjust the usual construction and maintenance programs to fit the new requirements and conditions. Some will be called upon to maintain on less money than has been available in the past, either because of a diversity of traffic to, or to provide funds for, other parts of the system. Others will be more fortunate and some, probably for the first time, will find available enough money to handle maintenance in an efficient manner.

J. M. R. Fairbairn—1926

A study of the committee reports during the life of the Association is a liberal education in the field of railway location, construction and maintenance, as well as giving much enlightenment on many features of operation.

To follow the work of the Association through its annual Proceedings gives one a most comprehensive idea of the improvement in the art of manufacturing transportation, and at the same time shows clearly what has been done to simplify practice and to standardize materials and structures, all of which tends to the maximum of efficiency in the personnel and economy to the companies.

The twenty-six volumes, of which the annual Proceedings consist, and the Manual, giving the recommended practice of the Association, constitute a reference library which no railway officer can well afford to be without. The recommended practice of the Association on any particular subject is clearly set forth in the Manual, and the considerations leading up to such recommended practice may be found in the committee reports, while the discussion by the membership at large on the same subject, as called forth at the annual meeting, is readily available in the Proceedings.

With this information at hand, any railway officer, even though not a member of the Association, can get a very fair idea of the best American practice and the reasons therefor, but to get the greatest value from the work of the Association it is necessary that one should be a member, busy working on one or more committees, or sub-committees, attending the meetings of these and participating in the committee discussions, where all the details of any subject are thoroughly thrashed out.

To the committee member the opportunity is afforded of intensive study of interesting problems which arise in his daily work, but instead of struggling alone with these problems he has the great advantage of conferring with a group of others, equally interested with himself in the same problem, having varied experience on other railways affected by different conditions of organization, traffic, physical formations and climate.

This study, coupled with the opportunity to meet and get to know personally a large number of others in the same line of effort, is a distinct advantage to any man, broadening tremendously his point of view and, consequently, enhancing his value to the company which he serves. Many committees, by so locating their meetings that their members can see and study various structures, layouts or methods, have given their members opportunities for such study seldom obtained by the individual officer.

*C. F. W. Felt—1927

While the proper design and construction are of prime importance, it is also desirable to bring out clearly the economies that will result from the adoption of improved methods. This is illustrated by the report of the Committee on Wood Preservation, which includes service test records showing average renewals over a five-year period of less than 120 ties per track mile per year for three roads having a total mileage of about 7800 miles, as against an average of 194 for twenty-five roads with a total mileage of about 198,000. While it should be noted that this low rate of renewal may not be the most economical for some of the roads, on the other hand it is likely that further improvement in wood preservation methods will reduce the low average thus far attained.

Incidentally, the reports show an improvement in prescribing tolerances more definitely. Instead of the over-exact "perfect fit" and the indefinite "workmanlike job," precise limits are given which are of much assistance to all and especially to the inexperienced, and it is also important because it tends to reduce inspection differences or disputes with the manufacturer or builder.

D. J. Brumley—1928

A review of the work done by your Association in the past twenty-nine years invites some speculation as to its work for the succeeding generation of Engineers. It is clear that the need for new rail lines and extensions is almost satisfied and it would appear that the work for the immediate future would be the orderly development of rail lines in existence. The railways are susceptible of great improvements, such as reduction of grades, elimination of curvature, construction of diversion lines around congested centers, shortening of lines and the extension and use of block signals. It will be found that where property values are high and the acquisition of additional land is prohibitive, double-decking, and probably triple-decking of railway facilities will be found economical. Such improvements will, however, be quite costly and will not be undertaken unless the analyses of savings in operating costs to be offset by interest on additional investment will show resultant economy. Electrification no doubt will be extended, since it has great operating advantages over steam under given conditions, such as density of traffic, heavy grades, feasibility of operation in congested terminals a commutation service where frequent stops are made and operation under covered areas where air-right developments are justified. The steam locomotive, or some other form of self-contained unit, for many purposes has operating advantages, and the immediate future, at least, has many possibilities for its improvement and the development of internal-combustion and storage-battery locomotives. The growth of urban communities has consistently followed the establishment of rail transportation lines. The rail line which was once at the outer edge of the municipality is now in the congested center of the city. The terminal facilities which amply supplied the transportation needs a generation ago, must be moved farther away where there is available space unrestricted by highways.

W. D. Faucette—1929

We come now to next year's work. I am terminating a year in this office with a flood of pleasant memories and with the intensified feeling of great respect and admiration for the membership of this Association. Much has been accomplished and more is yet to be done. This Association is a school and education to those in the mood to receive it. No man is too old to learn, and you will at the close of this three-day session leave with new subjects assigned to carry to conclusion. May I repeat without fear of weakening the effect, that I desire to impress upon you the importance of the work that has been accomplished during the past year. In looking over the great field of endeavor and in contemplation of the vast data that has been accumulated in the past thirty years, I trust that I may not be misunderstood when I say that I believe it is well that we balance carefully in our Association work the two parts of our general efforts. What I mean to convey just here is, that we, as an Association, are engaged through our committees in a great deal of fact-finding operations, accumulation of data and recording them in a concise and historical way. Now in order that we may deduce from this effort spent in fact-finding and observations I feel we must be sure as a body, both in committee-work and speaking in a collective sense, that we plan our work of reaching proper conclusions and establishing principles of recommended practice with the same relative assignment of weight to these two points as

* Deceased.

will give an equal value to both the efforts spent in the accumulation of data and the efforts spent in deriving principles and making engineering deductions. Let us not overbalance these two functions in our Association work, that without such balance we may have in our files a storehouse of information that may not be well assimilated. I feel in the past we have well-balanced this situation, but with the present modern methods and facilities by which we may accumulate data from all channels, let us ever keep before us the fact that I have just expressed, balance deduction with accumulation of data.

Louis Yager—1930

In conclusion, it seems appropriate that an analysis of your affairs be followed by at least a brief summary of the assets and liabilities of your Association. The dominant asset may aptly be described as consisting of a selected body of open-minded earnest men giving freely of their time and talents, and impelled by a motive of self-improvement, resulting from a collective contribution to the welfare of an important industry to which they have a personal or professional relation. The motive of self-improvement is commendable in that it is accompanied by an evident desire to give as generously as they receive. The ambition to be of service is manifested through the liberal contributions in a voluntary organization, often made at the expense of considerable personal inconvenience. There exists a fine spirit of whole-hearted cooperation with allied organizations in the discussion and solution of mutual problems in the economies of industry as well as in some of the less tangible spheres of human relations. The interest is keen in anticipating the trend of events which may require a modification of method. In rounding out the first generation of existence there are being established traditions of professional ideals and achievements. The pride in these traditions will constitute a worthy asset as long as they are kept free from the destructive influences of narrow self-sufficiency.

The liabilities are largely current ones, in that they relate to the material resources which must be provided to satisfy the needs of a healthy institution continually growing in size and importance. The stimulation of the founder purpose of the organization has expanded the outlook and further increased the useful productive capacity of the workers through the exercise of their functions in contacting with the complex demands of the transportation industry. There has therefore been created an obligation to maintain an open field of opportunity for the workers, in order that the organization may not suffer from the deteriorating effects of unemployment; a symptom of maladjustment whenever it continues for long periods in any industry. The increase in membership, well beyond the fondest hopes of those associated with its early history and the limits which eventually should be attained, naturally involve important questions of organization and direction. The natural group leadership always present in an intelligent democratic institution endowed with a mission of service will be amply able to devise ways and means to prevent these obligations becoming permanently fixed liabilities.

G. D. Brooke—1931

A most effective device of leadership is that which so suggests possible courses of action that they will be adopted and developed by those who must carry them out as their very own. The successful leader recognizes that he can gain little through pride in the origination of ideas or the authorship of plans. It is results he wants and since the burden of producing these results must fall upon the rank and file of the organization, to that organization belongs the credit for the achievement. He knows the great importance of maintaining a high *e'sprit de corps*, that men take pride in being a part of an organization of high standing, and that they glory in upholding its records and its reputation; he recognizes that adequate rest and recreation, comfortable sleeping quarters, healthful surroundings, good working conditions, competent supervision, strict but fair discipline and appropriate recognition of meritorious action and results will bring out the best in the individual and foster such a spirit of teamwork and pride in the organization that high-class performance will be spontaneous. Fortunate indeed is the railway officer who masters the principles, the practice, and the spirit of such leadership.

The President:—We will now hear the reports of the Secretary and of the Treasurer.

Secretary E. H. Fritch:—The report of the Secretary will be found on pages 133–167 inclusive of Bulletin 345 for March.

Committee-work constituting the major activities of the Association, that subject is first dealt with in the report.

Abstracts of the Committee reports presented by the various Committees reveal that you have been well served during the past year. One hundred and twenty-nine subjects are covered in the respective reports.

The participation of members in committee-work by railways is given in statistical form. It is of interest to note that over one-third of the total membership have collaborated in Committee activities.

Under the heading "Publications," reference is made to the three publications issued by the Association to disseminate its activities, namely, the Bulletin, the Proceedings and the Manual of Recommended Practice.

There has been a slight loss of members over the number reported on a year ago. Prevailing business conditions account for this situation.

The classification of the membership, as related to the several branches of the railway service, is an interesting exhibit.

The list of Railway Executives who are affiliated with the Association is included in the report. The table showing the geographical distribution of the membership indicates the international character of the Association, twenty-nine countries other than the United States having representatives in the Association.

The representation by railways and mileage of the roads with which the members are connected are also given.

We regret to record the loss by death of forty-five members since the last annual meeting. The list of deceased members includes eight Charter Members, one being also a Past-President.

A reference to the financial statement and general balance sheet discloses that the Association is in a healthful condition.

The quotations from presidential addresses 1900 to 1931 inclusive are made part of the report in the belief that a reading of these abstracts will prove interesting and illuminating at this time.

The report of the Treasurer is given on page 148. It shows the receipts and disbursements, and also the status of the Stresses in Track Fund, of which the Association is custodian.

Mr. President, I move that the reports of the Secretary and of the Treasurer be approved.

The President:—What is your pleasure, gentlemen?

(The motion to approve the reports of the Secretary and Treasurer was regularly seconded, put to vote and carried.)

The President:—We shall now proceed with the regular business of the convention. Of necessity, our time is short. One of the outstanding reasons this organization is successful is its traditional ability to meet whatever conditions have confronted it. These have been extraordinary. Although the time will be short, we do not want to curtail discussion more than necessary, but we urge you to be prompt in attendance, and to make your discussions as short as they may be to cover your point, that we may proceed to a quick determination on each report and finish our program within the allotted time.

I hope it will not be necessary in future years to curtail the meetings as we shall have to curtail this one, but existing conditions have justified this, and certainly we are the people that can meet those conditions.

The next order of business is the report of the Committee on Uniform General Contract Forms, Mr. F. L. Nicholson, Chief Engineer of the Norfolk Southern, Chairman.

(For Report, see pp. 65–106)

The President:—The second report is that of the Committee on Iron and Steel Structures. Mr. A. R. Wilson, Engineer of Bridges and Buildings of the Pennsylvania Railroad, is Chairman of that Committee.

(For Report, see pp. 107–108)

The President:—We will next have the report of the Committee on Wooden Bridges and Trestles. Mr. H. Austill, Bridge Engineer of the Mobile & Ohio Railroad, is Chairman of that Committee. Mr. Austill will please present the report.

(For Report, see pp. 243–257)

The President:—Next we will have the report of the Special Committee on Clearances, Mr. A R. Wilson, Chairman.

(For Report, see pp. 109–110)

The President:—The report of the Committee on Electricity will be presented by Mr. Sidney Withington, Electrical Engineer of the New York, New Haven & Hartford.

(For Report, see pp. 111–112)

The President:—The next report is that of the Committee on Signals and Interlocking. This will be offered by Mr. A. H. Rudd, Chief Signal Engineer of the Pennsylvania Railroad, in the absence of the Chairman.

(For Report, see pp. 509–515)

AFTERNOON SESSION

The President:—The first order of the afternoon's session is consideration of the report of the Committee on Yards and Terminals. Mr. H. L. Ripley, Construction Engineer of the New York, New Haven & Hartford Railroad, is Chairman, and will make the introductory remarks.

While the Committee is coming to the platform, the Chair will announce the appointment of Mr. B. B. Shaw and his associates as Tellers for counting the ballots. The Secretary will turn the ballots over to the Tellers, who will canvass the votes and be prepared to make a report at the close of the session tomorrow, Wednesday afternoon.

(For Report, see pp. 113–147)

The President:—We will now have the report of the Committee on Shops and Locomotive Terminals. Mr. L. P. Kimball, Engineer of Buildings, Baltimore & Ohio Railroad, is Chairman, and he will please indicate what action he wants taken on this report.

(For Report, see pp. 439–473)

The President:—Next, we will have the report of the Committee on Standardization. This will be presented by Mr. J. C. Irwin, Valuation Engineer of the Boston & Albany, Chairman of the Committee.

(For Report, see pp. 149–160)

The President:—The next report will be that on Maintenance of Way Work Equipment, and the report will be submitted by Mr. C. R. Knowles, Chairman, Superintendent of Water Service of the Illinois Central System.

(For Report, see pp. 161–192)

The President:—The report of the Committee on Rules and Organization will be presented by Mr. E. H. Barnhart, Industrial Engineer of the Baltimore & Ohio, Chairman, and he will please summarize the report.

(For Report, see pp. 337–347)

The President:—The report of the Committee on Grade Crossings, Mr. J. G. Brennan, Engineer of Grade Crossings, New York Central, Chairman, is the next report to be considered.

(For Report, see pp. 497–508)

EVENING SESSION

The President:—The first report of the evening session is that of the Committee on Rivers and Harbors. Mr. E. A. Hadley, Chief Engineer of the Missouri Pacific Railroad, Chairman.

(For Report, see pp. 207–241)

The President:—We will next have the report of the Committee on Roadway, with Mr. C. W. Baldridge, Assistant Engineer of the Atchison, Topeka & Santa Fe Railway, as Chairman.

(For Report, see pp. 297–335)

The President:—The report of the Special Committee on Stresses in Railroad Track will be presented by Dr. A. N. Talbot, of the University of Illinois, as Chairman.

(For Report, see pp. 369–370)

WEDNESDAY, MARCH 16, 1932

MORNING SESSION

The President:—Mr. J. E. Teal, Special Engineer of the Chesapeake & Ohio Railway, Chairman of the Committee on Economics of Railway Operation, will proceed with the presentation of his report.

(For Report, see pp. 193–205)

The President:—We will next hear the report of the Committee on Economics of Railway Labor. Mr. F. M. Thomson, District Engineer, Missouri-Kansas-Texas Lines, Chairman, will please outline his report.

(For Report, see pp. 371–403)

The President:—The report of the Committee on Water Service and Sanitation, Mr. R. C. Bardwell, Superintendent Water Supply, Chesapeake & Ohio Railway, Chairman, is next on the program.

(For Report, see pp. 259–295)

The President:—The report of the Committee on Buildings will be presented by Mr. A. L. Sparks, Architect, Missouri-Kansas-Texas Lines, Chairman.

(For Report, see pp. 405–438)

The President:—Next is the report of the Committee on Masonry, with Mr. Meyer Hirschthal, Concrete Engineer of the Delaware, Lackawanna & Western Railroad, as Chairman. Mr. Hirschthal will please summarize his report.

(For Report, see pp. 621–663)

AFTERNOON SESSION

The President:—The report of the Special Committee on Waterproofing of Railway Structures will be presented by the Chairman, Mr. J. A. Lahmer, Senior Assistant Engineer, Missouri Pacific Railroad.

(For Report, see pp. 367–368)

The President:—Next is the report of the Committee on Records and Accounts. Mr. C. C. Haire, Engineer of Capital Expenditures, Illinois Central System, is Chairman of this Committee.

(For Report, see pp. 587–620)

The President:—We will now have the report of the Committee on Ballast, with Mr. A. P. Crosley, Division Engineer of the Reading Company, as Chairman.

(For Report, see pp. 349–366)

(Past-President Louis Yager in the Chair.)

Past-President Louis Yager:—Will the Committee on Ties please come forward? In the absence of the Chairman, Mr. W. J. Burton, due to illness, the report will be presented to you by Mr. John Foley, Assistant Purchasing Agent, Pennsylvania Railroad, the Vice-Chairman.

(For Report, see pp. 475–495)

The President:—The Chair would ask unanimous consent to interrupt the regular proceedings of the meeting for a few minutes, as Mr. L. C. Fritch, one of our Past-Presidents, has a matter he would like to present at this time.

Mr. L. C. Fritch (Chicago, Rock Island & Pacific):—Mr. President, I have been delegated by this Association to thank you for the splendid service you have rendered the organization as a member of the Association, as a member of its Board of Direction, and as its President, and also for the splendid service you have rendered this Association in its contact with the American Railway Association. We have always found we had a friend at court through you.

It has been said by some bankers that the railroads are burdened with too many Lawyer Presidents. Be that as it may, I do know that if the railroads had more Engineer Presidents, such as is represented by Mr. Baldwin, I think we would be better off (Applause).

You have rendered to this Association a most inestimable service. The splendid record you have made as an Executive of railways needs no comment here, but it reflects added luster upon this Association. I therefore offer, on behalf of the entire Association, and second it at the same time, the following resolution:

> "The American Railway Engineering Association records its grateful appreciation to Lewis Warrington Baldwin for valuable services rendered as President in 1931–1932. He gave freely and generously of his time and effort to promote the welfare and interest of the American Railway Engineering Association and under his progressive leadership the standards, ideals and traditions have been maintained on the high plane of the past."

I ask the membership to arise to approve this resolution.

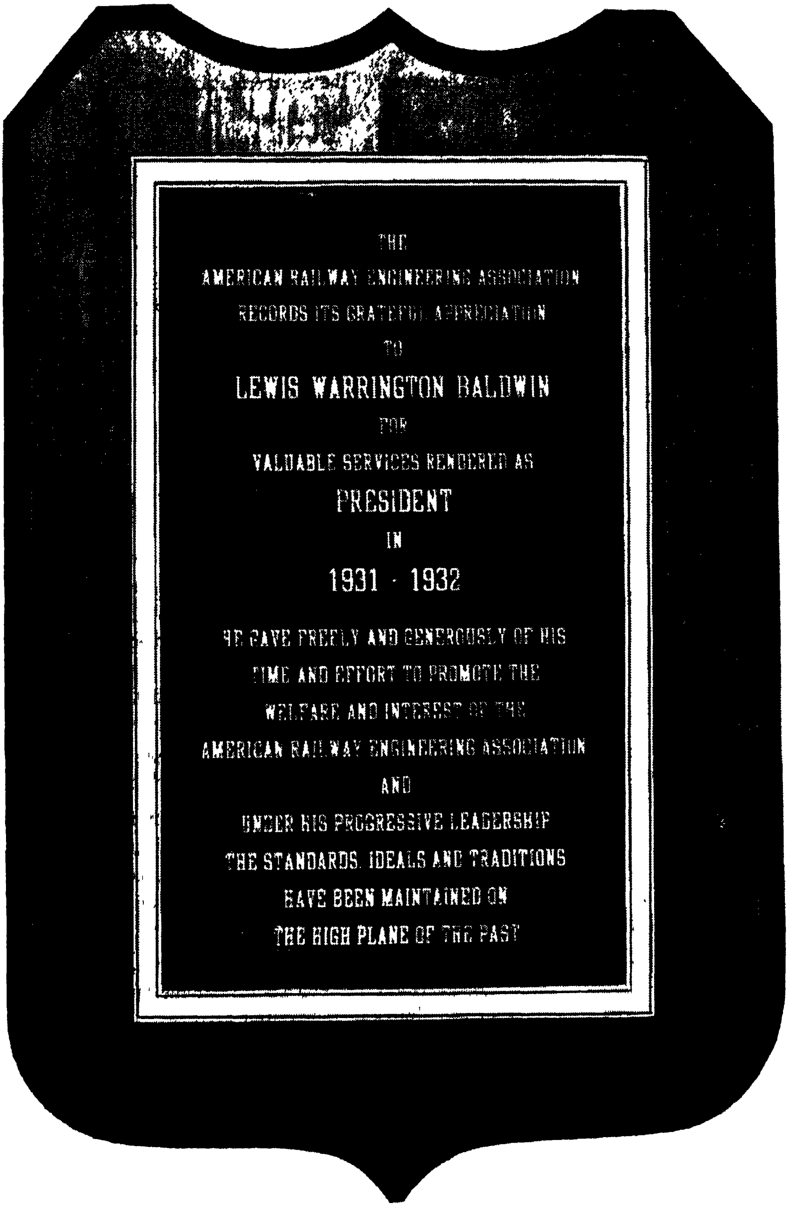
(The audience arose and applauded.)

Mr. L. C. Fritch:—On behalf of the Association, Mr. Baldwin, I present you this plaque which embodies the resolution just read, which I hope you will accept with the thanks of this Association (Applause).

The President:—Mr. Fritch and Members of the Association: I shall attempt later on to express my gratitude, but I cannot let this moment pass without saying to you that I deeply appreciate your statements, the thought it embodies, and though probably undeserved, I cannot help but feel "puffed up" after hearing what you have had to say (Applause).

We will now resume the regular procedure. The next report is that of the Committee on Wood Preservation. This report will be presented by Mr. F. C. Shepherd, Consulting Engineer of the Boston & Maine Railroad, Chairman.

(For Report, see pp. 517–554)


THE
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TO
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FOR
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IN
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The President:—The report of Committee IV—Rail, will be presented by Mr. Earl Stimson, Chief Engineer of Maintenance, of the Baltimore & Ohio Railroad.

(For Report, see pp. 555–578)

The President:—We will next have the report of the Committee on Track, which is the last Committee report, but by no means the least important. The Chairman is Mr. C. R. Harding, Assistant to the President of the Southern Pacific Company.

(For Report, see pp. 579–586)

The President:—This completes consideration of Committee reports.

The next order of business is "New Business." Is there any new business to come before the meeting?

Mr. H. R. Safford (Missouri Pacific):—The following resolution is offered:

> "RESOLVED, That the appreciative thanks of the Association be expressed to the Honorable Claude R. Porter, Chairman of the Interstate Commerce Commission, for his interesting and instructive address before this Association during the Thirty-third Annual Meeting."

I move the adoption of that resolution.

(The motion was regularly seconded, put to vote and carried.)

Mr. W. G. Arn (Illinois Central):—In his admirable address, for which we are thanking Mr. Porter, he makes some excellent suggestions which I think the Association might well take action on.

I know of no better way to further the enactment of some of his suggestions than through taking them up through Congress, that is, Senators and Congressmen, in our own states and districts. In order to be sure that we are not putting anything in these letters that shouldn't go in, it seems to me it might be well for the Board of Direction to outline what the members might write in their personal letters to their Senators and Congressmen, and let it be sent out by the Secretary to all the membership so that we may bring this to the attention of Senators and Congressmen all over the country.

The President:—Does anyone else have anything to offer in the way of "New Business"?

Gentlemen, I should now like to express to you my appreciation for the plaque which has been given me by you, through Mr. Fritch, and for the splendid things he has had to say. I only want to say that if anything I have done has contributed any benefit to this Association, and, through it and the membership, to the railroad industry, I am truly grateful for the opportunity.

I can say without hesitation that I do truly appreciate the thought and the expression, and shall ever treasure the plaque, the expression on it, and the means by which it was conveyed, and shall think of you always in appreciation.

It has been a pleasure to me, and I consider it a great honor, to serve you as President during the past year. There have been no unpleasantnesses connected with this work, which I cannot say about much of any other work we have had to do during the past year. What work I have been able to do for the Association has been done with the true feeling that I loved the work, and considered it a real honor to be able to serve.

I would like to take this opportunity to thank all the officers of the Association, all the Directors of the Association, its competent Secretary, Mr. Fritch, the heads of all Committees and Sub-Committees for their support during this period.

I also want to express the thought, which I have had impressed upon my own mind, that the Committee reports are excellent, and reflect real study and work. I think it pertinent to comment that, at a time like this, when everybody has been tried, and the pressing nature of our own immediate problems has taken much of the time of the members of this Association, they have found time—and where they have not found time they have made it—to carry on the work of this Association. The Association, as such, and the membership, as such, truly are indebted to each member of these Committees. The reports were presented in the clearest manner, and the Chairmen and Sub-Chairmen are to be congratulated.

It would be amiss if I did not also express to you, the members, an appreciation of the attention you have given all the Committees when they presented their reports. I am appreciative of the discussions that were had, but am particularly impressed with the real attention given these men while they were presenting their reports.

There were several suggestions made last night at a small dinner which I attended to the effect that it probably would be wise for this Association now to broaden out a bit and subordinate some of the subjects that heretofore have been important, but which now appear to be of lesser importance, and substitute therefor some new more timely and constructive subjects. I hope that the Committee on Outline of Work will give this real consideration.

It appeals to me that we should be pleased that there was a registration of 757 at this convention—643 members, and 114 guests, which is exceptionally fine, considering the existing conditions and that the convention was only for two days, and that many of the attractions that heretofore have been furnished in connection with the Association meetings, such as the exhibits at the Coliseum, were missing. It is really marvelous that we have had such an attendance.

I should like to reiterate that my service to you has been a pleasure to me, and if I have been of help to you I am indeed gratified (Applause).

As there seems to be no further "New Business", the Secretary will announce the result of the election of officers for the ensuing year.

The Secretary:—"Report of Tellers. We, the Committee of Tellers, report the following as the result of the count of the ballots:

For President:

J. V. Neubert........1247 votes

For Vice-President:

John E. Armstrong........1244 votes

For Secretary:

E. H. Fritch........1247 votes

For Treasurer:

A. F. Blaess........1246 votes

For Directors (Three to be elected):

A. N. Reece........597 votes
J. C. Irwin........596 votes
E. M. Hastings........508 votes
A. R. Wilson........488 votes
E. R. Lewis........366 votes
F. R. Layng........339 votes
H. Austill........281 votes
J. R. Watt........273 votes
L. S. Rose........266 votes

For Members Nominating Committee (Five to be elected):

E. L. Crugar	851 votes
W. T. Dorrance	710 votes
C. P. Richardson	655 votes
J. W. Orrock	639 votes
C. B. Bronson	615 votes
W. C. Barrett	551 votes
W. L. Morse	534 votes
R. C. Young	532 votes
A. L. Sparks	493 votes
M. Hirschthal	446 votes

(Signed) COMMITTEE OF TELLERS,
By B. B. SHAW, *Chairman.*

The officers elected are:

President:

J. V. Neubert, Chief Engineer Maintenance of Way, New York Central Railroad, New York City.

First Vice-President:

W. P. Wiltsee, Chief Engineer, Norfolk & Western Railway, Roanoke, Va.

Second Vice-President:

John E. Armstrong, Assistant Chief Engineer, Canadian Pacific Railway, Montreal, Quebec, Canada.

Secretary:

E. H. Fritch, Chicago.

Treasurer:

A. F. Blaess, Chief Engineer, Illinois Central System, Chicago.

The three Directors elected are:

A. N. Reece, Chief Engineer, Kansas City Southern Railway, Kansas City, Mo.

J. C. Irwin, Valuation Engineer, Boston & Albany Railroad (N. Y. C. R. R.), Boston, Mass.

E. M. Hastings, Chief Engineer, Richmond, Fredericksburg & Potomac Railroad, Richmond, Va.

The five members elected to the Nominating Committee are:

E. L. Crugar, Chief Engineer, Wabash Railway, St. Louis, Mo.

W. T. Dorrance, Assistant to Chief Engineer, New York, New Haven & Hartford Railroad, New Haven, Conn.

C. P. Richardson, Engineer of Track Elevation, Chicago, Rock Island & Pacific Railway, Chicago.

J. W. Orrock, Engineer of Buildings, Canadian Pacific Railway, Montreal, Quebec, Canada.

C. B. Bronson, Assistant Inspecting Engineer, New York Central Railroad, New York City. (Applause)

The President:—There being no further business to come before the meeting, the Chair asks Past-Presidents Brumley and Stimson to escort the President-Elect to the rostrum.

(President-Elect Neubert was escorted to the platform by Past-Presidents Brumley and Stimson.)

The President:—Mr. Neubert, I want to congratulate you on your election to this important position, and can only hope you will have the same loyal support I have had, which I predict you will, and that you will serve this Association as President in an entirely satisfactory and efficient manner, and I bespeak for you complete success (Applause).

(Retiring President Baldwin surrendered the gavel to President-Elect Neubert, who assumed the Chair as President of the Association.)

President-Elect Neubert:—Mr. Baldwin and Members of the American Railway Engineering Association: It seems that I have not words to express my appreciation for this recognition which you have given me in electing me to the highest office you have in this organization. I wish I did have the words to tell you what is in my heart.

I have served this Association on a number of Committees. I have gained from that committee-work not only plans, specifications, and the application of engineering, but a broader scope whereby I have gained much that is valuable beyond my own individual railroad with regard to its application in use. Beyond that, I have gained more from the Association itself through coming in contact with its members, because I feel they represent the greatest thing there is, and I think it is an expression of God that they have character and personality.

There is no question that in the last two years particularly we have been under a depression, or unfortunate period, but I cannot help thinking of the life of that great statesman, Abraham Lincoln, who had reverses practically all through his life and how he always came out and felt that that ordeal would be solved.

I feel, my friends, that what we should do is to carry on and think of Lincoln; that we should go forward with our heads up, looking to the future. I know you are going to help me in carrying on.

I believe I can sum up the feelings of all of you here, which are mine, that was said in a verse over one hundred years ago:

> No speed like this can fastest horse compare,
> No weight like this can canal or vessel bear,
> For this let sons of commerce grant thy vote,
> To this, let sons of commerce cast their vote.

Thank you (Applause).

Are there any further suggestions or remarks before the Association adjourns? If not, the Chair declares the convention adjourned *sine die*.

E. H. Fritch

Secretary.

COMMITTEE REPORTS

REPORT OF COMMITTEE XX—UNIFORM GENERAL CONTRACT FORMS

F. L. Nicholson, *Chairman;*
C. Frank Allen,
E. H. Barnhart,
Calvin Bartlett,
W. H. Brameld,
B. S. Dickerson,
R. P. Eubank,
W. D. Faucette,
F. H. Fechtig,
B. Herman,
J. C. Irwin,
A. C. Jackson,
W. G. Nusz, *Vice-Chairman;*
J. S. Lillie,
S. L. Mapes,
A. A. Miller,
O. K. Morgan,
C. B. Niehaus,
H. A. Palmer,
Charles Silliman,
Huntington Smith,
J. S. Thorp,
C. A. Wilson,
John S. Worley,

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following assignments:

(1) Revision of Manual (Appendix A). It is recommended that no revision be made at this time.

(2) Form of Agreement for the Purchase of Electrical Energy in Large Volume (such as required for traction purposes), collaborating with Committee XVIII—Electricity (Appendix B). It is recommended that the "Form of Agreement for the Purchase of Electrical Energy in Large Volume" be accepted as a progress report and the subject continued.

(3) Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project, collaborating with Committee XIV—Yards and Terminals (Appendix C). It is recommended that the "Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project" be approved for publication in the Manual.

(4) Form of Conveyance of Title Granting the Right to Construct and Maintain Air Right Buildings over Railway Property (Appendix D). It is recommended that the report be accepted as information and the subject continued.

(5) Form of Agreement for Pipe Line Crossings under Railway Tracks, collaborating with Committee XIII—Water Service and Sanitation (Appendix E). It is recommended that the report be accepted as progress and the subject continued.

Respectfully submitted,

The Committee on Uniform General Contract Forms,

F. L. Nicholson, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

J. C. Irwin, Chairman, Sub-Committee; W. H. Brameld, W. D. Faucette, O. K. Morgan, W. G. Nusz, Charles Silliman.

Your Committee has no revisions to recommend at this time.

Bulletin 340, October, 1931.

Appendix B

(2) FORM OF AGREEMENT FOR THE PURCHASE OF ELECTRICAL ENERGY IN LARGE VOLUME (SUCH AS REQUIRED FOR TRACTION PURPOSES)

W. H. Brameld, Chairman, Sub-Committee; E. H. Barnhart, J. C. Irwin, S. L. Mapes, H. A. Palmer, J. S. Thorp.

Your Committee reports progress with Form of Agreement for the Purchase of Electrical Energy in Large Volume. A tentative draft of the form was prepared and submitted to Committee XVII of the Electrical Section for criticism and suggestion. They were reviewed and a revised draft dated July 8, 1931 prepared, based on the suggestion of the Electrical Section. This revised draft is now in the hands of the Electrical Section for further criticism or approval. It has also been submitted to the Railway Electrification Committee of the National Electric Light Association for criticism or approval.

Action Recommended

That this be accepted as a progress report, that the revised draft dated July 8, 1931, be printed in the Proceedings as information and a basis for criticism and suggestion and the subject be continued.

INDEX

THIS AGREEMENT, made this .... day of ...., 19...., by and between.....................
...., a corporation organized and existing under the Laws of the State of ...., hereinafter called the "Power Company", and ...., a corporation organized and existing under the Laws of the State of.................., hereinafter called the "Railway Company",

WITNESSETH:

WHEREAS, the Railway Company desires to purchase and take from the Power Company and the Power Company desires to sell and deliver to the Railway Company, during the term hereof, electric energy (hereinafter called "energy") estimated to be initially about .... kilowatts of billing demand (as hereinafter defined) for electric operation of certain portions of the Railway Company's system comprising ....
....,
all of which lines are located as shown on map dated ...., designated ....
....,
marked "Appendix A", attached hereto and made a part hereof, and for other purposes as hereinafter provided.

NOW, THEREFORE, in consideration of the covenants and agreements herein contained, to be performed by the parties hereto and of the payments hereinafter agreed to be made, it is mutually agreed as follows:

ARTICLE I

TERM OF AGREEMENT

The term of this agreement shall be .... (..........) years, commencing on ...., or on such earlier date as the Railway Company may designate by written notice to the Power Company at least twelve (12) months prior to such earlier date; subject, however, to termination as provided in Article VIII.

ARTICLE II

OBLIGATIONS AS TO SUPPLY AND PURCHASE

For and during the term hereof the Power Company shall supply and deliver, and the Railway Company shall purchase and take from the Power Company, in accordance with and subject to the terms, provisions and conditions herein contained, the energy used within the territory hereinbefore defined, for or in connection with the electric operation of trains and for non-traction purposes connected with or incidental to the construction, maintenance, use and operation of the Railway Company's properties, whether occupied or used by it as a common carrier or otherwise, or leased or sub-leased to tenants or sub-tenants; provided, however, that:

(Insert here the provisions as to proportion of requirements to be supplied; resale; limits of supply to tenants; generation at existing Railway Company plants; supply to other railways using the Railway Company's tracks; regeneration; increasing demands and other provisions of special nature.)

In the event of failure of the Power Company's supply of energy, the Railway Company shall have the right to use during such failure for any purpose energy acquired from any other available source.

Incidental flow of energy through the Railway Company's circuits from other power sources shall not be considered contrary to the intent of this Article.

ARTICLE III

CHARACTER OF SERVICE

The energy to be supplied hereunder shall be in the form of .... phase, ... wire, ... cycle, alternating current and at a voltage of nominally .... volts per phase and/or direct current at a voltage of nominally .... volts.

The frequency and voltage at the points of delivery shall be as constant as practicable, considering the characteristics of the Railway Company's load and the operating requirements of the Power Company's system.

Under normal conditions of operation on the Railway Company's system and on the Power Company's system, the voltage variation at the points of delivery shall not exceed .... per cent (...........%) above or below the normal voltage of .... volts.

ARTICLE IV

CHARACTER OF LOAD

The type, arrangement and operation of the equipment used by the Railway Company in connection with the energy taken hereunder shall be such as will not materially interefere with the operation of the Power Company's system and service to its other customers.

The power factor of the Railway Company's system during periods of heavy demand shall not be less than .... per cent (...........%).

ARTICLE V

POINTS OF DELIVERY

The energy to be supplied hereunder shall be delivered by the Power Company to the Railway Company and measured at the following points:

(Railway Substations, Power Company Generating Stations, Power Company Substations, Etc. Specify method of connection and ownership of facilities.)

ARTICLE VI

RATES AND PAYMENTS

Section 1. For each calendar month of the term hereof, the Railway Company shall pay to the Power Company the following:

(a) An amount of money known as the Primary Charge equal to............... Dollars ($.........) per kilowatt of Billing Demand for that month. Such Billing Demand shall be the maximum demand for the month ascertained in accordance with Section 2 of this Article, or .... per cent (...........%) of the greatest previous maximum demand during the last preceding twelve months, whichever is the greatest; provided, however, that the Billing Demand for each month during the first year of said term shall be the actual maximum demand for that month and the maximum demand for each such month shall be ignored in determining the Billing Demand for any subsequent month.

(b) An amount of money known as the Secondary Charge, equal to .... mills ($0.......) per kilowatt hour of energy furnished hereunder during each month, subject to the addition or deduction of ....../1000ths of a mill ($........) per kilowatt hour for each ....Cents (.........¢) of increase or decrease

from the average delivered cost per unit of fuel of .... Dollars and .... Cents ($............).

(NOTE: It may be desirable to have either or both the Primary and Secondary Charges in blocks. Also, consideration should be given to the effect of variations in labor costs and to the variations in cost per kilowatt hour at switchboard of hydro-electric plants.)

The number of kilowatt hours to be used in computing the Secondary Charge for any month shall be not less than .... per cent (............%) of the equivalent of the Billing Demand for such month if used during each and every hour of that month.

Section 2. As soon as practicable after the end of each calendar month the Railway Company's maximum demand in kilowatts for such month shall be ascertained as follows:

From each of three days in the month there shall be selected one even clock hour which shall be the hour of greatest combined draft of the day from which it is taken; and said three days shall be such that the sum of the combined drafts of the three hours selected therefrom in the manner thus indicated shall be greater than the sum of the combined drafts of three hours similarly selected from any other three days in the month. One-third of the sum of the combined drafts of the three hours selected as aforesaid from each month shall be taken and considered as the number of kilowatts constituting the Maximum Demand.

Said combined draft during any even clock hour shall be the amount of energy measured in kilowatt hours, or shall be .... per cent (..........%) of the resultant integrated product of voltage and current, measured in kilovolt-ampere hours, whichever shall be greater, and shall be construed as representing a single quantity of energy, or .... per cent (............%) of the resultant integrated product of voltage and current, as the case may be, taken hereunder at the several points of delivery just as though the various quantities were measured and integrated as one quantity at one point.

If in any month the Railway Company shall require an abnormal energy supply caused by excessive or congested traffic beyond that usually handled by the Railway Company due to storm, accident, complete or partial failure of the Power Company's supply of energy, derangement of the Railway Company's power facilities, or any other emergency condition, the Power Company will, if it has sufficient capacity available at the time, supply such abnormal demand, provided the Railway Company shall give the Power Company prompt notice of such abnormal demand by telephone or otherwise, confirming such notice by letter within forty-eight (48) hours. The Railway Company agrees, however, to promptly reduce the demand to normal upon notification from the Power Company that such reduction is necessary to preserve the general service of the Power Company. In ascertaining the Maximum Demand for such month, hours in which such abnormal demand or demands occur shall not be selected unless such abnormal demands occur in .... or more consecutive days; and in the latter event, hours in which such abnormal demands occur may be selected from any of such consecutive days following the .... of such consecutive days, but such hours shall be ignored in determining the Billing Demand for any month subsequent to the month in which such abnormal demand occurred and shall be ignored in determining the minimum number of kilowatt hours to be used in computing the Secondary Charge for that month.

Section 3. The Railway Company shall have the right at all reasonable times to examine and make copies of all meter and other records of the Power Company used in the computation of bills rendered hereunder.

Section 4. All payments for charges incurred under the provisions of this agreement during any calendar month shall be due and payable .... (........) days after receipt of the bill therefor.

In case payment of a charge be not made on or before the day upon which it becomes due, interest shall accrue upon such charge at the rate of .... per cent (..........%) per annum from the date on which it becomes due. In case the Railway Company questions the correctness of any bill, it shall nevertheless make payment of the full amount thereof. When decision or agreement with respect to the questioned bill is reached, the Power Company shall refund the over-payment, if any, together with interest thereon at the rate of .... per cent (......%) per annum from the date on which such bill was originally paid.

Article VII
METERING

Section 1. All energy furnished under this agreement shall be measured at the points of delivery by meters to be installed and maintained by the Power Company at its expense.

Section 2. The instruments to be installed by the Power Company shall be of a standard type and manufacture and shall accurately measure the energy in electric units and periods of time as required by the terms of this agreement. The Railway Company shall have the right to be represented at the readings of these instruments and at the testing, adjusting or changing thereof.

Section 3. All meters shall be tested and calibrated by the Power Company every .... month(s) by comparison with accurate standards, and if as the result of any test a meter shall be found to be inaccurate, it shall be restored to an accurate condition or an accurate meter shall be substituted by the Power Company. Either party to this agreement shall have the right to require that a test be made of any meter at any time. The party desiring such test shall make request therefor in writing upon the other party and thereupon such meter shall be tested and calibrated by the Power Company, and if it shall be found inaccurate it shall be restored to an accurate condition or an accurate meter shall be substituted by the Power Company. If as a result of any test any meter shall be found to register in excess of two (2%) per cent either above or below normal, then the readings of such meter previously taken shall be corrected, but no such correction, either in respect to demand or kilowatt hours drawn or consumed, shall extend back beyond thirty (30) days previous to the date on which such inaccuracy shall be discovered by such test, and if during such previous thirty (30) days one or more prior tests shall have been made under the provisions hereof, then no such correction shall extend back beyond the date of the last of such prior tests.

The Power Company shall give to the Railway Company reasonable notice of the time when any test will be made as hereinbefore provided.

If any special test of any meter shall be made at the request of the Railway Company with the result that such meter shall be found to register correctly or within two (2%) per cent of normal, then the Railway Company shall bear the expense of such test. The expense of all other tests shall be borne by the Power Company.

Article VIII
INTERRUPTION, DEFAULT AND TERMINATION

Section 1. The Power Company shall use all due diligence in providing a regular and uninterrupted supply of energy, but in case the supply of energy shall be inter-

rupted, be defective or fail for any cause, the Power Company shall not be liable therefor, except as otherwise herein provided.

If, however, such failure occur, the Railway Company shall be entitled to a proportionate and equitable deduction from the Primary Charge for the month in which said failure occurred, provided claim for such deduction be made within thirty (30) days after the end of the month in which the failure of delivery occurred.

Section 2. If in any month the Power Company shall be unable to deliver energy to the Railway Company, either in whole or in part, as required to be delivered by it under the provisions of this Agreement, or the Railway Company shall be prevented from operating its regular train service, either in whole or in part, by strike, riot, insurrection, civil or military authority, fire, explosion, act of God, railway accident, the complete or partial failure of the supply of energy from any other source, or by any other cause reasonably beyond its control, and if such inability and/or prevention shall cause the Railway Company's consumption of energy in such month to fall below the minimum amount specified in item (b) of Section 1 of Article VI hereof, then the number of kilowatt hours to be used in computing the Secondary Charge for such month shall be not less than the sum of

(a) the number of kilowatt hours which would equal .... per cent (..........%) of the total number of kilowatt hours which the power represented by the Billing Demand for such month could produce, if exerted during each and every hour of that month except the hours in which such inability and/or prevention occurred, and

(b) the number of kilowatt hours supplied during the hours in which such inability and/or prevention occurred.

Section 3. It is recognized that the Railway Company must receive from the Power Company a regular and uninterrupted supply of energy in accordance with the provisions of this Agreement, in order to make this Agreement of value to it; and if for any reason interruption of such supply of energy shall be so frequent or of such duration as to interfere materially with the operation of its lines of railway, or if the amount, quality or character of the energy delivered hereunder shall not be in accordance with the provisions of this Agreement, then the Railway Company may notify the Power Company thereof in writing, specifying the grounds of complaint, and the Power Company shall forthwith remedy the trouble so specified and provide a full, regular and uninterrupted supply of energy in accordance with the provisions of this Agreement. If the Power Company shall fail to do so with reasonable diligence and promptness and in any event within ninety (90) days from the date of such notice, the Railway Company shall have the right at its option to terminate this Agreement by giving to the Power Company thirty (30) days' notice in writing of its intention so to do, stating in such notice the date of proposed termination, and this Agreement shall terminate upon the date of termination specified in said notice; provided, however, that if on any earlier date the Railway Company shall be able to obtain elsewhere the necessary energy required for the operation of its railway lines and shall give the Power Company notice in writing of such fact, this Agreement shall terminate upon the date of such later notice.

Section 4. The Railway Company shall have the right at its option to terminate this Agreement if the rates and charges herein specified shall be increased, pursuant to or by operation of law; also, the Railway Company shall have the right at its option to terminate this Agreement without assigning any cause therefor at the end of the .... year of the term or at the end of any twelve (12) months period thereafter. In case of any termination as provided for in this section, the Railway Company shall give to the Power Company not less than eighteen (18) months' notice

in writing of its intention so to do, and this Agreement shall terminate upon the date of termination specified in such notice; provided, however, that upon such termination the Railway Company shall purchase from the Power Company such conversion and transmission apparatus and facilities as shall be then in use solely for the delivery of energy to the Railway Company under this Agreement. The purchase price shall equal the actual cost less the sum of annuities of .... per cent (........%) per annum of such actual cost from the time such apparatus and facilities shall first have been placed in operation for the sole benefit of the Railway Company to the date of termination. The actual cost of apparatus and facilities installed at the commencement of the term hereof for the sole purpose of delivering energy hereunder is hereby agreed to be .... ($...........) Dollars.

Section 5. If the Railway Company fails to pay any bill of the Power Company as provided for in Article VI within ninety (90) days after such bill is due, the Power Company shall have the right to terminate this Agreement by giving to the Railway Company not less than thirty (30) days' notice in writing of its intention so to do, stating in such notice the date of proposed termination, and this Agreement shall terminate upon the date of termination specified in said notice.

Section 6. If the type of the equipment or if the operation of the equipment used by the Railway Company in connection with the energy taken hereunder interferes materially with the operation of the Power Company's system and service to its other customers, then the Power Company may notify the Railway Company in writing specifying the grounds of complaint and the Railway Company shall forthwith remedy the trouble so specified. If the Railway Company shall fail to do so with reasonable diligence and promptness and in any event within ninety (90) days from date of such notice, the Power Company shall have the right to terminate this Agreement by giving to the Railway Company not less than thirty (30) days' notice in writing of its intention so to do, stating in such notice the date of proposed termination, and this Agreement shall terminate upon the date of termination specified in said notice.

Article IX
REDUCTION IN RATES

If at any time during the term of this Agreement, the Power Company shall deliver energy to any other consumer for service under similar conditions at a total rate or charge which shall be lower than that hereinbefore given to the Railway Company, and such lower rate or charge shall not be justified by different conditions of service, making the cost of production and delivery to such other consumer relatively less than to the Railway Company (and the burden of proving such different conditions of service justifying the lower rate or charge shall be upon the Power Company), then and in that event and so long as such lower rate or charge shall be given to such other consumer while this Agreement is in force, the Railway Company shall be entitled to a reduction in its said rate or charge equal to so much of the amount of the difference between such lower rate or charge and the Railway Company's said rate or charge as shall not be so justified.

Article X
ARBITRATION

In case any question arises under this Agreement or concerning the subject matter thereof, upon which the parties hereto cannot agree, such question shall be settled by a sole, disinterested arbitrator, to be selected jointly by the parties to this Agreement, and if they fail to select such arbitrator within .... (..........) days after demand for arbitration is made by either party hereto, then such arbitrator shall be appointed by the Judge of the .... Court of ....

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as may be determined by the arbitrator.

Article XI
GENERAL

Section 1. The Power Company shall have right of access to the premises of the Railway Company at all reasonable times during the period of this Agreement, and on its termination, for the purpose of reading meters, inspecting or repairing appliances used in connection with its service, removing its property, or for any other purpose proper under this Agreement.

The Railway Company shall not permit access, except by authorized employees of the Power Company, to the meters or other appliances of the Power Company, nor interfere with the same, and their safe keeping shall be provided for by the Railway Company.

Section 2. Whenever either party shall install any conduit, cable, wire or other apparatus or equipment in or upon the premises of the other party under any provision hereof, the party owning the same shall have the right, upon giving due notice to the other party, to repair or remove such apparatus or equipment at any and all reasonable times, provided such repair or removal shall not interfere with the carrying out of this Agreement; and upon the termination of this Agreement by lapse of time or otherwise, such party shall at its own cost and expense, remove promptly and permanently any and all property owned by it upon the premises of the other party. Upon the removal of any property by either party from the premises of the other party as aforesaid, the party removing the same shall at its own cost and expense restore said premises to the same or as good condition as existed prior to the placing of said property thereon.

Section 3. The Railway Company agrees to indemnify and save harmless the Power Company from all cost, expense or liability for damages, which may arise or result from the use, care or handling of the energy delivered hereunder after the same shall have been delivered to the Railway Company at the points of delivery specified in Article V hereof, or from the presence upon the premises of the Railway Company of any appliances of the Power Company, except that the Power Company shall be responsible for all claims of its own employees, agents and servants.

The Power Company agrees to indemnify and save harmless the Railway Company from all cost, expense or liability for damages which may arise or result from the use, care or handling of the energy delivered hereunder before the same shall have been delivered to the Railway Company at the points of delivery specified in Article V hereof, or from the presence upon the premises of the Power Company of any appliances of the Railway Company, except that the Railway Company shall be responsible for all claims of its own employees, agents or servants.

Section 4. Any waiver or any number of successive waivers of any of the rights that may accrue to either party hereto through the default of the other party in keeping and performing any of the terms or obligations of this Agreement shall not estop the party so waiving the default from asserting and having the benefit of its rights in accordance with the terms of this Agreement upon any other or subsequent default, but at any time during the life of this Agreement either party shall have the rights and benefits herein provided in case of default by the other party, without regard to any prior waivers or the number or time of such prior waivers.

Section 5. This Agreement shall inure to the benefit of and be binding upon the legal representatives and successors of the parties respectively; provided, however, that this Agreement shall not be assigned by the Power Company unless such assignment

shall be made to another company having equal facilities to effectually perform, and which shall covenant to perform, the obligations herein of the Power Company.

In Witness Whereof, the parties hereto have executed this Agreement the day and year first above written.

The............................Company

By ....
President.

Witness............................ (Seal—Power Company)

Attest ....
Secretary.

Witness............................

The............................Company

By ....
President.

Witness............................ (Seal—Railway Company)

Attest ....
Secretary.

Witness............................

Appendix C

(3) FORM OF AGREEMENT FOR THE ORGANIZATION AND OPERATION OF A JOINT PASSENGER TERMINAL PROJECT

W. G. Nusz, Chairman, Sub-Committee; B. S. Dickerson, W. D. Faucette, A. C. Jackson, A. A. Miller, C. A. Wilson and John Worley.

Your Committee submitted to the 1930 Convention a preliminary draft of the Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project, printed on pages 494 to 524 of Bulletin 320. In 1931, your Committee again called attention to the preliminary draft printed in Bulletin 320 and asked for suggestions or criticisms of the form. It has continued to study this subject and has been in constant touch with Committee XIV, Yards and Terminals. The latter Committee has made a number of very helpful suggestions and the two committees are now in accord.

Your Committee now submits a final draft of the agreement, divided into two parts—the first or "Organization Agreement", provides for the creation of a railway company to operate and maintain the terminal; the construction and method of financing it; and the second or "Operating Agreement" can be fully executed only after the Terminal Company has been legally created and has authorized its officers to execute the agreement. Both parts must be considered at the same time as constituting one complete agreement.

Your Committee recommends the adoption of this form, as recommended practice and that it be printed in the Manual.

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Operating Agreement:

FORM OF AGREEMENT FOR THE ORGANIZATION AND OPERATION OF A JOINT PASSENGER TERMINAL PROJECT

IN TWO PARTS—EACH A SEPARATE AGREEMENT

Part 1—Organization Agreement

This organization agreement provides for the creation and incorporation of a Terminal Company with power to finance, acquire, construct, control, manage, operate and maintain a joint passenger terminal. It shall be executed by the railway companies interested in, or owning, or possessing a right in the project.

Part 2—Operating Agreement

This operating agreement provides for the financing, acquisition, construction, control, management, operation and maintenance of the terminal, and for the admission of railway companies other than the incorporators, to the joint use of the terminal. It shall be executed by the same companies that executed the organization agreement, and in addition by the Terminal Company.

FORM OF AGREEMENT FOR THE ORGANIZATION AND OPERATION OF A JOINT PASSENGER TERMINAL PROJECT

ORGANIZATION AGREEMENT

(Form Prepared For Use By Three Interested Railway Companies)

THIS AGREEMENT, made this .... day of .... 19...., by and between ...., a corporation organized and existing under the laws of the ...., hereinafter called the .... (A) .... Company; ...., a corporation organized and existing under the laws of the .... hereinafter called the .... (B) .... Company and ...., a corporation organized and existing under the laws of the ...., hereinafter called the .... (C) .... Company, all collectively hereinafter called the Companies.

WITNESSETH:

WHEREAS, the Companies are now, or are about to become, operating railway companies with passenger train service, in the City of ...., State of .... and the passenger business of the Companies demands more extensive and better regulated station, transfer and other facilities in said city than is afforded at present, and

WHEREAS, the Companies desire to facilitate and expedite such transfer and other business and for that purpose desire to consolidate their passenger business at one location, and

WHEREAS, the Companies desire (a) to cause a corporation to be created under the laws of the .... to acquire, construct and operate a passenger terminal station and other necessary or convenient facilities in connection therewith, suitably adapted to furnishing passenger terminal facilities to the parties hereto, all collectively hereinafter called the "Terminal", in the City of ...., and/or (b) to enter into an agreement to provide for the financing, acquisition, construction, control, management, operation, and maintenance of such a Terminal, to apportion the earnings and expenses thereof, and define the liabilities of the Companies; and,

WHEREAS, the Companies also desire (a) to procure the necessary legal authority to enable them to enter into such an agreement and to secure control by acquiring the capital stock of the proposed corporation; (b) to assume obligation and liability in respect to its bonds and other evidences of indebtedness; and (c) during the time interval between the date hereof and the date when the necessary authority shall have been obtained, and the proposed agreement entered into, to use their best efforts to acquire or cause to be acquired the necessary real estate and carry on or cause to be carried on the construction of the Terminal as hereinafter provided for in this Agreement,

NOW THEREFORE,

Section 1. The Companies agree promptly to cause a corporation to be created under the laws of the .... of .... and under the name of the .... (hereinafter called the Terminal Company) with powers to exercise the right of eminent domain, and to issue stock, bonds and other evidences of indebtedness and to acquire, and/or construct, and/or operate the property and facilities described and herein referred to as the Terminal in the form of agreement attached, marked and hereinafter referred to as Operating Agreement, and hereby made a part hereof; and further agree that the capital stock of the Terminal Company shall be .... ($..........), consisting of .... (.........) shares of the par[a] value of .... ($.........)[b]. Each of the Companies agrees that the shares shall be equally divided (or as may be agreed) between the Companies and that each Company will subscribe or cause such subscription to be made therefor. All shares shall be held subject to the conditions provided in the Operating Agreement.

The Companies further agree to cause the Terminal Company to make application for all necessary legal authority to issue said stock, bonds and other evidences of indebtedness and to acquire and operate the property and facilities described and herein referred to as the Terminal in the form of agreement attached, marked and hereinafter referred to as Operating Agreement and hereby made a part hereof, and to execute and comply with the terms of the Operating Agreement; and the Companies also agree to apply for any legal authority necessary to enable them to acquire or cause to be acquired the stock of the Terminal Company and to enter into and comply with the terms of the Operating Agreement.

Each of the Companies, if and when such authority is obtained, agrees to execute and to comply fully with all the terms and conditions of the Operating Agreement and to cause the Terminal Company to execute the same. Said Operating Agreement, in the exact form and language of the attached draft thereof, shall be signed and executed by the Companies hereto and by the Terminal Company.

Section 2. Each of the Companies owning any lands or other property or rights therein within the Terminal Area, as defined in the Operating Agreement, hereby agrees that such lands or other property or rights may be taken by the Terminal Company at such time as it may elect for use in constructing the Terminal, payment to be made for the same as provided in the Operating Agreement. It is further understood and agreed that on the lands to be acquired within the Terminal area, as defined in the Operating Agreement, whether from the parties hereto or from others, or on any substitute lands acquired in lieu of any land within the Terminal area which may not be acquired, there shall be constructed a passenger terminal with all necessary or convenient facilities

[a] If capital stock of no par value is issued, then changes to provide for such stock must be made in the agreement where necessary.

[b] Where state laws require that qualifying shares be set aside for the incorporators who may also be directors, it should be included at this point.

and appurtenances, all with sufficient capacity to provide properly for the passenger business of the Companies. If the acquisition of the property and/or any of the details of construction and the exact locations are not defined or fixed in the Operating Agreement, they shall be subject to approval by the Companies.

It is understood and agreed that the tentative plans for said additional improvements have been worked out by authority and at the expense of the Companies but said plans may be changed or enlarged from time to time, as further study and developments make it advisable to make such changes or enlargements, either prior to the execution of the Operating Agreement or thereafter during the time the parties hereto continue in charge of the work of constructing the Terminal as provided in the Operating Agreement.

During the time intervening between the date of this agreement and the date when conveyance of the property owned by the Companies is made to the Terminal Company, the Companies shall appoint a Committee to acquire or cause to be acquired the title to or use of the real estate, public or private, within the Terminal area, necessary for the project, and the Companies shall, pending the incorporation and organization of the Terminal Company, construct or cause to be constructed, improvements thereon, substantially in accordance with the "General Plan" marked Plan .... and attached to the Operating Agreement, or in accordance with such plan as the same may be changed by agreement of the Companies, but any and all details in connection with construction or acquisition of property shall be approved by the .... of each of the Companies.

It is agreed that the Companies shall keep construction accounts, showing items of all construction work heretofore or hereafter done by them, for which payment is to be made by the Terminal Company, and that the Companies shall also keep accurate and complete accounts of all revenues and operating expenses from the beginning of the acquisition of the property or start of any construction work, up to the date of conveyance to the Terminal Company.

It is further agreed that the Companies shall forward to the .... Company, monthly, a detail of all of the charges made by each of them to the various accounts covered in this paragraph, and the .... Company shall combine and keep a complete record of all such accounts, turning them over to the Terminal Company when it assumes control and operation of the Terminal.

All accounts kept by each Company with reference to receipts and/or expenditures to be credited or charged to the Terminal, shall be open for examination by each of the other Companies and shall conform to all requirements of the Operating Agreement.

Section 3. It is agreed that the Terminal Company shall, upon request of any Company, operate such parts of the Terminal as may be put in service from time to time for the account and benefit of that Company, without discrimination in favor of, or against any railway company using the Terminal.

Section 4. The capital stock shall be paid for in cash at the time or times required under the terms of the Operating Agreement.

Section 5. This agreement is made subject to all Federal and State laws and all rules or orders, supplements or amendments thereto now of record and now in force or to be made by any board, commission or body having competent jurisdiction and in the event it shall be found to conflict with any of such laws, acts, rules or orders, it shall be amended to conform therewith.

In Witness Whereof, the Companies hereto have caused this agreement to be signed in triplicate by their duly authorized officers, and their respective corporate seals

to be hereunto affixed and duly attested by their respective Secretaries or Assistant Secretaries, the day and year first above written.

ATTEST:	.... (A) ....
.... Secretary.	By ....
ATTEST:	.... (B) ....
.... Secretary.	By ....
ATTEST:	.... (C) ....
.... Secretary.	By ....

FORM OF AGREEMENT FOR THE ORGANIZATION AND OPERATION OF A JOINT PASSENGER TERMINAL PROJECT

OPERATING AGREEMENT

(Prepared For Use By Three Interested Railway Companies)

THIS AGREEMENT, made this .... day of ...., 19...., by and between ...., a corporation organized and existing under the laws of the ...., hereinafter called the ......(A)...... Company; ...., a corporation organized and existing under the laws of the ...., hereinafter called the ......(B)...... Company; ...., a corporation organized and existing under the laws of the ...., hereinafter called the ....(C)....... Company; the ....(A).......Company, ...(B)...... Company, and ......(C)...... Company are hereinafter collectively called the Companies, and ...., a corporation organized and existing under the laws of the ...., provided for in the organization agreement and hereinafter called the Terminal Company,

WITNESSETH:

WHEREAS, the Companies entered into a certain Organization Agreement on the .... day of ...., 19...., providing for the organization of a Terminal Company and also providing for the acquisition and/or construction and the operation of a passenger station, equipment terminal and other necessary or convenient facilities and appurtenances in ...., hereinafter called the Terminal, and,

WHEREAS, said Organization Agreement provided among other things for the creation of a Corporation under the laws of the .... and this provision having been complied with and the Terminal Company, party hereto being legally incorporated in compliance with the Organization. Agreement and having the necessary approval of the governmental bodies having jurisdiction, is prepared to proceed with the construction, operation and maintenance of the passenger station and facilities designated in the organization agreement as the Terminal and,

WHEREAS, the Terminal Company having received all legal authority required for issuing and selling its capital stock, bonds and other evidences of indebtedness, and the Companies having received all legal authority necessary to enable them to secure control of the Terminal Company by the purchase of said capital stock as set forth in the Organization Agreement,

NOW THEREFORE, in consideration of the covenants and agreements herein contained, it is mutually agreed as follows:

ARTICLE I

CORPORATE EXISTENCE

Protection of Rights and Privileges

Section 1. The Terminal Company agrees that it will not do or omit any act, the doing or omission of which might operate, directly or indirectly, to forfeit any of the rights, privileges or franchises acquired under its charter, or howsoever acquired, or which in any manner might impair the value of its privileges, rights, or property, or its ability to perform all of its obligations in this agreement provided for, and shall at the expiration of the present term of its corporate existence cause the same to be renewed and extended in the manner and form as may then be provided by law, and shall cause similar renewals and extensions to be made from time to time as the same shall be necessary to maintain its existence and the corporate power with which it is now vested.

Exercise of Corporate Power

Section 2. The Terminal Company agrees that in order to enable it to carry out the provisions of this agreement, it shall at all times and from time to time, when requested by the Companies, or any of them, put forth and exercise each and every corporate power and do each and every corporate act which the Terminal Company may now or at any time hereafter lawfully and properly put forth or exercise to enable the Companies, and each of them, to enjoy and avail themselves of and exercise every right, franchise and privilege hereby granted, in the proper management and operation of the Terminal, according to the terms of this agreement.

ARTICLE II

TRUSTEE, STOCKS, BONDS AND OTHER EVIDENCES OF INDEBTEDNESS

Appointment of Trustee

Section 3. There shall be a Trustee appointed by a majority of the Companies within .... (........) days after the date of this agreement. Such appointment shall be by written instrument, specifying all the terms and conditions of this agreement insofar as they apply to the Trustee. The appointment of a Trustee as herein provided and acceptance of the trust by the Trustee under the terms of this agreement shall be effectual to vest in such Trustee, so appointed, the absolute authority, rights, powers and duties provided in that behalf.

Method of Financing

Section 4. The Terminal Company shall finance the acquisition of the necessary lands and leasehold interests, the construction of the Terminal, a reasonable fund for working capital, and future additions and betterments as follows:

Sale of Capital Stock

1. By the sale of .... Dollars ($........) of capital stock, consisting of .... (........) shares of a par[a] value of .... Dollars ($........) each to be equally divided among the Companies, each Company having subscribed for .... (........) shares thereof.

Sale of Bonds

2. By the sale of its first mortgage gold bonds in a total amount not exceeding .... Dollars ($........) such bonds to be issued in series secured by a

[a] See note a, Section 1, Organization Agreement.

. first mortgage upon all its property and franchises made to the Trustee, each series maturing .... (........) years from the date of issue of such series, or otherwise as may be agreed upon.

Each series of bonds shall be for such amounts, shall bear interest at such rate and shall be issued on such terms as may be agreed upon by the Terminal Company and the Companies; any series may be made redeemable, at the option of the Terminal Company, at such price and under such terms and conditions as may be agreed upon by the Terminal Company and the Companies.

Sale of Notes or Collateral Trust Bonds

The Terminal Company may also, from time to time, issue notes or collateral trust bonds, secured by pledge of the mortgage bonds, pending a sale of the mortgage bonds.

Failure to Approve Bond Issues

During the time the Companies shall fail or refuse to agree to the issuance of notes or bonds, or to the terms thereof, no liability shall arise from the Terminal Company to the Companies or any of them on account of the failure of the Terminal Company to proceed with the construction of the Terminal. Any Company or Companies, failing or refusing to agree to such issuance of bonds within .... days, shall be liable for any damage or injury incurred by said other Company or Companies on account of such failure or refusal to agree to such issuance of bonds and shall be considered in default as hereinafter provided.

Provisions Protecting Bond Holders

The mortgage shall contain such provisions for the protection of the holders of the bonds issued thereunder, and of the Trustee therein, as the Terminal Company may adopt in its corporate capacity.

Bonds—Guaranteed by Companies

The Terminal Company shall apply to such commission or commissions, or other governmental bodies as may be by law required, for authority to issue such bonds, and the Companies at the same time shall apply for authority to and shall jointly and severally guarantee, by endorsement thereon, the due and punctual payment of the principal and interest of all of the Terminal Company's bonds to be issued as herein provided.

Funds Advanced for Construction

Section 5. The Companies shall, during the period of construction of the Terminal, advance to the Terminal Company as loans .... Dollars ($..........) equally apportioned between the Companies and bearing interest at the rate of .... per cent (......%) per annum and in addition thereto such sums as may be necessary to enable the Terminal Company to meet its requirements for taxes, rentals and interest upon its bonds then outstanding or on its interest bearing indebtedness incurred on account of the acquisition of lands, leasehold interests or on account of construction, which additional sums shall bear interest at the same rate as the prior issue of the Terminal Company's then outstanding, and which loan shall be repaid by the Terminal Company out of the proceeds of the next issue of bonds disposed of under this agreement. The amount of advances, required by the necessities of the Terminal Company from time to time, shall be fixed by the Board of Directors of the Terminal Company and the resolution of said Board of Directors shall be final as to the amount thereof.

ARTICLE III

ISSUE OF STOCK—VOTING POWER OF STOCK

Issuance of Stock Certificates

Section 6. When the payments provided for in this article are made, the Terminal Company shall issue, in the names of the respective Companies making such payment, certificates representing shares of stock of the Terminal Company, equal at par value to the amount of such payments, and such payment shall be held and considered to be the purchase price (at par) for the amount of capital stock represented by such certificates and shall be so applied by the Terminal Company.

Delivery of Stock Certificates

The Terminal Company shall deliver each stock certificate when issued to the Company in whose name it was issued.

Voting Power

Section 7. Any Director of record representing a share holding Company not in default, and/or any stockholder of record not in default shall be entitled to vote at all meetings of the stockholders of the Terminal Company for the election of directors and for all other purposes, upon all of the shares of the Terminal Company transferred hereunder to the Director or Company.

ARTICLE IV

PAYMENT FOR STOCK

Subscription for Stock

Section 8. The Companies have each subscribed or have caused subscription to be made for their account for .... shares at par value of the capital stock of the Terminal Company.

Method of Payment

Section 9. Payment for said capital stock shall be made as follows:

(a) Each Company shall pay, to apply on their respective subscriptions, an amount equal to .... of the total amount necessary to enable the Terminal Company to carry out its obligation and to make the payments required under paragraph (b) of this Section.

(b) The Terminal Company, from time to time, if and when necessary to secure funds, shall, by appropriate resolution or order of the Board of Directors, call for such amounts of the respective subscriptions of the Companies, in cash, as may be sufficient to yield the necessary funds and each of said Companies agrees upon receipt of such demand to make such payment within ten days thereafter.

Advance Notice by Terminal Company

The Terminal Company shall endeavor to give reasonable advance notice to the Companies of the dates when it expects to apply for funds, but failure to give such notice shall not relieve any Company from the obligations hereby assumed to make such payments within ten days after demand is made therefor.

Default in Payment

In the event that any Company shall fail to make such payment within ten days after receipt of any such demand the Terminal Company shall immediately notify, as provided in this agreement, the other Companies not in default.

Final Payment

(c) The total amount of the payments to be made by the Companies under this Section shall equal the par value of the capital stock subscribed for by them. On completion of the Terminal, the Terminal Company shall certify that it desires to collect all amounts, if any, then remaining unpaid, on account of the respective subscriptions for capital stock by the Companies and shall make demand on the Companies therefor, as provided above in this Section.

Article V

MANAGEMENT

Terminal Area

Section 10. It is agreed between the Companies and the Terminal Company that the Terminal shall include within its limits all of the land, tracks, property, and appurtenances or facilities indicated and shown on the map marked "General Plan," hereto attached.

Direction and Control in Terminal Company

Section 11. The management, operation, maintenance, repair and renewal of the Terminal shall be under the exclusive direction and control of the Terminal Company, but all rules and regulations issued by the Terminal Company shall be reasonable, just and fair to each of the Companies, and without preference in favor of or discrimination against any of them. Each Company shall cause its employees to comply with all rules and regulations so issued, and it shall make deliveries to and receive cars from the Terminal Company at such times and places, in such manner and under such rules and regulations as the Terminal Company may direct.

Control Exercised by Board of Directors

Section 12. The direction and control of the Terminal Company shall vest in and be exercised by its Board of Directors, referred to in this agreement as "Board of Directors," composed of .... members, with an Alternate for each member empowered to act only in the absence of such member unless otherwise provided in Section 17 hereof; .... of which .... members with a corresponding number of alternates shall be representatives of and nominated by each of the Companies hereto and the persons so nominated shall be elected by the stockholders of the Terminal Company at an annual meeting for that purpose. In the event a vacancy occurs among the Directors or Alternates elected by the stockholders, the Company, to which the vacancy appertains, shall have the right to nominate the Director to fill said vacancy and such nominee shall be elected at the next meeting of the Board to fill such vacancy.

Executive Committee Authorized

The Board of Directors may by a vote of two-thirds of the members thereof, create an Executive Committee composed of .... members of said Board to

transact business ordinarily coming before the Board during intervals between meetings of said Board, and which shall be subject to approval of the Board of Directors at its next meeting.

Board of Directors to Supervise Terminal

Section 13. The Board of Directors, through the officers of the Terminal Company shall have charge and supervision of the entire Terminal, and the use thereof for the passenger, mail, express and other business of the Companies shall be subject to such impartial and reasonable regulations as may, from time to time, be adopted by the Board of Directors.

Operating Organization and Control

Section 14. The Board of Directors shall adopt such By-Laws and Rules as may be necessary for the control and operation of the Terminal, be responsible for all property of the Terminal Company and shall elect, as provided in said By-Laws, a President, a Vice-President, a Secretary, a Treasurer, an Auditor and a Terminal Manager, and shall control and regulate their actions.

Companies' Employees Under Supervision of Terminal Company

Section 15. When operating within the limits of the Terminal, all employees of any of the Companies hereto or any other railway company hereafter admitted to the use of the Terminal, shall be subject to the same control of the Terminal Manager as employees of the Terminal Company and shall observe and carry out all instructions or orders issued by him or his duly authorized representative.

Employees to Practice Neutrality

All officers and employees of the Terminal Company shall at all times practice strict neutrality between the Companies using the Terminal.

Suspension or Removal of Employees

Any officer elected by the Board of Directors of the Terminal Company may be suspended or removed from service by a two-thirds vote of all the members of the said Board. Any general officer of any of the Companies using the Terminal may make a written demand upon the Terminal Manager of the Terminal Company for discipline or dismissal of an employee not elected by the Board of Directors of the Terminal Company, specifying the reasons therefor, and thereupon the Terminal Manager may discipline or dismiss the employee and shall report action taken by him to the Company making the written demand. If the Company is not satisfied, the action taken by the Terminal Manager shall be subject to review by the Board of Directors at its next meeting.

Expansion of Facilities

Section 16. It shall be the duty of the Terminal Manager, at all times to study and consider the needs of the service and the requirements of the Companies; and from time to time, as necessity may arise, to make recommendations for proper changes or alteration in and expansion of any part or all of the Terminal including additions and betterments to the property and any one or more of the Companies may at any time present plans for consideration of the Terminal Company suggesting such improvements.

Equal Representation

Section 17. Each of the Companies, so long as it is not in default hereunder, shall at all times have equal representation on the Board of Directors of the Terminal Com-

pany as provided in Section 12 hereof and whenever necessary the By-Laws or Charter of the Terminal Company shall be so amended, with respect to the number of its Directors, as to admit of equal representation by all such Companies upon said Board.

Train Schedules and Time Tables

Section 18. Each Company hereto shall have the right to arrange its own schedules and time tables for trains arriving at or departing from the Terminal. This right is subject, however, to review by the Terminal Manager and by the Terminal Company, and must be judiciously, fairly, and equitably exercised by each of the Companies in such manner as not to produce unnecessary inconvenience to any other Company. Should a disagreement arise between the Terminal Manager and any Company, between the Companies, or any of them, as to the arrangement of trains, or the time tables or train schedules, or any of them, the Board of Directors shall have the full power and authority to determine a reasonable arrangement and enforce the adoption thereof.

The Terminal Manager is hereby given full power and authority to regulate train movements and establish speed restrictions necessary for the safe and proper conduct of all traffic over and upon the Terminal, subject to review by the Board of Directors.

In case of dispute under this Section between the Terminal Manager and any Company, between the Companies or any of them, any one of them may appeal to the Board of Directors and its decision shall be final and binding.

Article VI

CONVEYANCES BY RAILWAY COMPANIES TO THE TERMINAL COMPANY

Terms of Conveyance

Section 19. Each of the Companies shall convey or cause to be conveyed to the Terminal Company, as herein provided, all its right, title and interest in and to all parts or parcels of land, together with all tracks and improvements on the same, now owned by it and lying within the Terminal, and shown on said "General Plan" marked Plan ...., subject to the provisions contained in this Section.

Special Warranty Deed

The parcels of land owned by the Companies and lying within the Terminal shall be conveyed to the Terminal Company by special warranty deed, executed by the Company owning the same and each of the Companies hereby agrees that it will have the parcel or parcels of land, to be conveyed by it, released from any and all mortgages or trust deeds which are or may be a lien thereon at the time of conveyance; and that it will guarantee the Terminal Company and any of its successors or assigns, possessing the power of eminent domain, against eviction from the parcels of land conveyed by it, except such parcels as may be lawfully taken for street purposes, provided the Terminal Company or any such successor or assign (a) does not voluntarily yield possession to third parties and (b) does notify the grantor of any claims asserted, by way of suit or otherwise; and does permit the grantor at the grantor's cost and expense to defend any suit or suits respecting title, and to condemn in the name of the Terminal Company or any such successor or assign, but at the cost and expense of the grantor, any interest so asserted. Each of said guaranties, however, is subject to the applicable provisions of this agreement.

The guaranty of the Companies is limited to the fair value of the parcels of land determined as provided in this agreement.

Companies' Option to Repurchase

The parcels of land conveyed to the Terminal Company under this Article shall be conveyed subject to an irrevocable option of each of the Companies making such conveyance to purchase them, at the price paid therefor by the Terminal Company, on the termination of this agreement as provided in Section 64 hereof or in event of an involuntary dissolution, or liquidation of the Terminal Company, its successors or assigns.

Payment for Companies' Land

Section 20. The Companies shall be paid by the Terminal Company for the parcels of land to be conveyed by them to the Terminal Company, such sums of money as shall be determined by agreement of the .... of the Companies heretofore or hereafter made, with simple interest at the rate of .... per cent (.......%) per annum from the date the land is taken by the Terminal Company for its use until the date the Companies receive payment therefor, or failing agreement, by arbitration proceedings conducted under this agreement as hereinafter provided. If any Company is inconvenienced or damaged by the taking of a part of that Company's property for use in the Terminal under the provisions of this agreement, then such Company shall be entitled to and receive damages in an amount to be agreed upon between that Company and the Terminal Company, or failing an agreement, by arbitration proceedings, conducted under this agreement as hereinafter provided.

Conveyance of Land to Terminal Company

Section 21. The Companies, each for itself, shall promptly take all steps and perform all acts preliminary to the making of the respective conveyances by it or them to be made, and to determine promptly, or have determined, the prices to be paid for the respective parcels of said lands and property to be conveyed under Section 19 hereof and to execute promptly and deliver simultaneously the conveyances in accordance with the details of this agreement, concurrently with the payment to them of the amounts to be paid by the Terminal Company, when such delivery is demanded and payment offered by the Terminal Company.

Division of Taxes and Special Assessments

Section 22. The Terminal Company shall assume and pay any and all special assessments or installments thereof, all taxes and other levies of every character, falling due and payable after the date of the special warranty deed, on any and all parcels of land conveyed to the Terminal Company by any of the Companies. When the conveyance to the Terminal Company is made, all special assessments, taxes or other levies due or collectible during that year shall be pro-rated between the Company conveying the parcel or parcels of land to the Terminal Company and the Terminal Company, on the basis of the length of time during the year the conveyance is made that each, the Company and the Terminal Company, had possession of the parcel or parcels.

Substitution of Lands

Section 23. It is agreed by the parties hereto that if it should be found not possible, or in the judgment of the Companies not practicable to purchase or acquire any part of the land within the area, shown on said plans as required for the Terminal, such other land or any substitute lands may be acquired in lieu thereof at a cost including the lands, tracks or other improvements, to be mutually agreed upon by the Companies, and the plans and specifications shall be altered or changed to permit the use of such other or substitute lands.

ARTICLE VII

CONSTRUCTION

Method of Procedure

Section 24. The Terminal Company agrees with the Companies and each of them that it shall (a) proceed with all reasonable dispatch to acquire title to, or the right to use all necessary land, public or private, to construct, complete and fully equip for occupancy and use a Terminal,[c] including all facilities and appurtenances necessary and convenient for railway purposes, or the traveling public using the same, as provided in the Organization Agreement, hereby made a part hereof, and with adequate capacity for the passenger business of the Companies and such other railway companies as may under this agreement hereafter use the Terminal, in accordance with such plans and specifications as may be prepared by the Companies and delivered to the Terminal Company at the time this agreement is executed and as provided herein; (b) maintain at all times the Terminal in good repair, condition and order; and (c) operate the Terminal for the purpose of furnishing passenger terminal facilities to the Companies and such other railway companies as may, under this agreement, hereafter use the same.

Plans and Specifications

Section 25. The Passenger Station, Equipment Terminal and other separate facilities comprising the Terminal, including such portions of the Terminal as are indicated on said "General Plan" and certain exhibits as follows ....[d] and with the specifications marked Exhibits ...., and ...., have been prepared by the Companies, are attached hereto and each and all are hereby made a part of this agreement. All plans and specifications hereto attached shall be authenticated by the signatures of the Chief Engineers of the Companies and the Terminal Company and may be changed or enlarged from time to time by mutual agreement of the Terminal Company and the Companies prior to or during construction.

In the event that during the construction of the Terminal the Companies mutually agree that additional facilities shall be provided within the area shown on any or all of said plans and they shall request the Terminal Company to construct such additional facilities, the same shall be constructed under the terms hereof.

ARTICLE VIII

USE, OPERATION AND RENEWAL

Use Granted to Companies

Section 26. The Terminal Company grants to each of the Companies (in common with the other Companies and such other railway companies as hereafter may be granted the right of user) in accordance with the provisions of this agreement and subject to all and singular the conditions, limitations and restrictions in this agreement contained, and under and pursuant to such rules and regulations as may, from time to time, be adopted by the Board of Directors, not inconsistent with this agreement, the

[c] List here if desired items which may or may not be included as, a passenger station and office buildings, mail and express buildings, concourse, train shed and appurtenances, with all necessary tracks for same, tracks, buildings, platforms, driveways, engine houses, machine and/or repair shops, storehouses, fuel stations, coach and car cleaning yards, plants for generating electricity and steam for light, power and heat.

[d] Enumerate here and list facilities or any of the separate parts thereof that it may be desired to restrict to certain uses.

right to the full, joint and equal use of the Terminal, including all separate facilities, and appurtenances hereinabove provided for, for all purposes connected with their passenger business[e] for which they might reasonably use the same if individually owned by them, in the proportion that their individual requirements may demand, based upon the relative amount and character of business done as compared with the total business of the Terminal and to the total of the facilities available.

Reserve for Retirement

Section 27. [f]There shall be created under direction of the Board of Directors and as fixed by said Board of Directors from time to time, a fund representing a reserve for retirement and replacement of physical parts of the Terminal except land, and such funds shall be equitably divided between the Passenger Station, Equipment Terminal and other separate facilities and shall, with accumulated interest, cover the cost of retirement or replacement of the separate parts of the Terminal on the expiration of their useful life. The amounts necessary for the creation of this fund shall be a proper charge for the use of the Terminal or the parts thereof and charged against the Companies using the same.

Insurance

Section 28. Insurance shall be carried at all times during construction and after completion in proper kinds, classes and amounts, so as to provide adequate protection against loss from fire, theft, etc., this insurance shall be carried with a commercial insurance company, or by arrangement through the insurance departments of the Companies, as approved by the Board of Directors.

Companies to Use Terminal Exclusively

Section 29. The rights and privileges granted to each Company in Section 26 hereof are subject to the full and prompt performance by that Company of the following conditions and covenants:

(a) Each Company shall use the Passenger Station in the Terminal as its principal and main passenger station in the City of .... and shall use said station for all of the passenger trains as described in Section 26 hereof which it operates into and out of the said City of .... during the term of this agreement.

(b) Each Company shall use the Equipment Terminal and other separate facilities as its principal and main passenger train, car, equipment and engine terminal for its trains operating into and out of said City of .... during the term of this agreement (enumerate exceptions, if any).

Notice of Completion

Section 30. When the Passenger Station, Equipment Terminal and other separate facilities are so far completed that they can be effectively used within thirty days by all the Companies, the Board of Directors shall determine the day, not less than thirty days thereafter, when the period of construction shall come to an end and shall so inform the Companies. Such date or in case of disagreement the date fixed by the Arbitrator, as hereinafter provided, shall be known and referred to in this agreement as the "end of the construction period." If upon the day so determined, any Com-

[e] Including certain specified suburban trains and excepting suburban or other trains operated elsewhere to be listed here.
[f] See note under Section 42 (b).

pany shall claim that the Passenger Station, Equipment Terminal and/or any separate facility are not ready for use, it may appeal to arbitration, as provided herein. The Arbitrator shall thereupon have jurisdiction to determine the date upon which the period of construction shall end, and shall constitute a continuing board for that purpose.

Failure to Use

Section 31. In the event that at or after the end of the construction period any Company shall fail, for any reason, to make use of the Terminal, such Company shall nevertheless be liable to the Terminal Company for the amount which would have been payable to the Terminal Company by such Company had it used the same in accordance with the terms of this agreement.

Railroad Connections to Terminal

Section 32. Each Company shall make, at its own sole cost and expense, such changes in its tracks or structures or such arrangements with other railroad companies as may be necessary to enable it to reach and use the Terminal at the point or points indicated as terminal limits on the Plans, provided for in Section 25 hereof. Such changes shall be made in ample time, so that no Company shall be prevented from using the Passenger Station, Equipment Terminal and separate facilities at the end of the construction period, and the failure to make any such changes shall be no reason for postponing the end of the construction period and shall not relieve such Company from any liability assumed hereunder.

Lease Concessions

Section 33. Any space within the Terminal not needed by the Terminal Company for its own use or for common use of the Companies, either buildings or land, may be leased or rented until needed for use by the Terminal, by order of the Board of Directors, for such length of time as they may direct, to individual carriers, to the Pullman Company, Express or Local Transportation Companies or others. Space may also be leased or rented when not so needed, for terms not exceeding .... years by the Terminal Company, under the jurisdiction of the Terminal Manager, for concessions such as stores, offices, shops, restaurants and like facilities suitable for accommodation of the public, subject to terms and rentals approved by the Board of Directors.

Special Service

Section 34. A schedule of charges shall be provided, approved by the Board of Directors, for any special service rendered to any particular Company, such as rent of equipment, interchange of freight, express, special handling of cars, shop work, etc. All such service shall be provided only to the extent that it may be done without prejudice to the common use of the property or operation of the Terminal.

The switching of cars by the Terminal Company between the Terminal and points outside the Terminal shall be paid for as special service at an agreed rate to be adjusted from time to time as conditions and changing costs may require.

Terminal Company to Appoint Agents

Section 35. The Terminal Company shall, as provided by the By-Laws, appoint all ticket and baggage agents who shall be the agents for all of the Companies and all other Railway Companies using the Terminal unless otherwise provided. The ticket and baggage agents shall act without discrimination and not in any way influence pas-

sengers where tickets are for sale between competitive points on lines of the companies using the Terminal. The Terminal Company shall be liable for all actions of the agents and account for all moneys received from sale of tickets or checking of baggage to each of the Companies or any other railway company using the Terminal.

Check of Agents Accounts

Section 36. All books and accounts of the Terminal Company shall at all reasonable times be open to the inspection of the proper officers or agents of the Companies and so much of the books and accounts of each of the Companies as shall relate to the affairs of the Terminal Company shall at all reasonable times be open to the inspection of the proper officers or agents of the Terminal Company.

Terminal Company to Maintain, Operate and Manage

Section 37. It shall be the duty of the Terminal Company to do all things necessary for the proper maintenance, operation and management of the Terminal and make all reasonable regulations appropriate to that end.

Interruptions to Full Use

Section 38. If the use of the Terminal shall at any time be interrupted, or traffic therein be delayed by any cause whatsoever, none of the Companies shall have any claim against any other Company, for loss or damage of any kind, caused by or resulting from such interruption or delay, nor shall any Company in any such case be entitled to any abatement or reduction of the payments to be made by it to the Terminal Company, as in this agreement provided.

Charges for Outside Service

Section 39. The Terminal Company, in handling any business outside the scope of this agreement, shall charge for its services, rates from time to time established by tariff, or, if not required by law to be published in a tariff, then such reasonable rates as are customarily charged for such service.

Article IX

ADMISSION OF OTHER RAILWAYS

Section 40. The Terminal Company shall at all times have the right to admit other railways entering the City of .... to the use of the Terminal or parts thereof, upon terms and conditions to be agreed upon in separate agreement between the Terminal Company and such other companies and with the approval of each and all of the Companies hereto.

The right of use herein specified in respect to any Company, party hereto, shall include, as part of the use of such Company hereunder, the use of the Terminals and facilities herein provided for by any Company controlling or controlled by such Company, party hereto, whether by lease, stock ownership or otherwise; and the right of use herein specified shall pass, subject to the terms and conditions of this agreement, to any Company successor of any Company, party hereto, by consolidation, merger or otherwise. Provided, however, that in the case of the succession or control of any Company, party hereto, by any other Company, party hereto, or in case of the succession or control of more than one Company, party hereto, by any other Company, the several obligations hereunder of such Companies, parties hereto, shall, upon such

succession or while such control continues, be the several obligations hereunder of such successor or controlling Company; but in such case, the Companies not involved in such succession or control shall have the option to purchase at cost (averaged to reflect the cost per share of all holdings of stock of the Terminal Company), and divide equally among themselves, as much of the stock in the Terminal Company as may give each Company equal holdings with every other, counting the Companies involved in such consolidation or control as one, such option to expire three years after such consolidation or control shall have become effective. In case of such consolidation or control and the exercise of said option to purchase stock, an appropriate reduction shall be made in the number of the members of the Board of Directors of the Terminal Company.

ARTICLE X

ACCOUNTING GENERAL

Payment by Companies

Section 41. The Companies shall pay the Terminal Company, for and in respect to the use herein granted of the Passenger Station, Equipment Terminal and other separate facilities, at the office of the Treasurer of the Terminal Company, from and after the end of the construction period, as hereinafter provided, a rental determined as follows:

Records and Accounts

The Terminal Company shall keep its accounts and records in accordance with the accounting, valuation or other orders of the Interstate Commerce Commission, so far as applicable, and as directed by the Auditing Committee of the owning companies, as hereinafter provided. The construction accounts shall be so kept as to show separately the costs of the Passenger Station, the cost of the Equipment Terminal, and the cost of other separate facilities comprising the Terminal, and the accounts shall be closed on completion of the construction work. A proper division of costs of items during construction which are not allocable, such as Supervision of General Officers, Office Expenses, etc., and including any taxes and interest during construction which might not be directly applicable to any particular facilities or portion of the Terminal, shall be distributed between the separate facilities on the same basis, that the relative direct charges, made against each of the facilities, bears to the total cost of the entire Terminal.

Statement of Monthly Expenditures

At least once in each ...., the Terminal Company shall prepare a schedule of the expenditures incurred in connection with the Passenger Station, the Equipment Terminal and other separate facilities respectively, with a sufficient description to identify the items, which, when approved by the Board of Directors, shall become the agreed statement of such cost. In case any Company is not satisfied with said accounting and agreed statement of cost, it shall have the right to appeal to arbitration, as hereinafter provided.

Subdivision of Records

After the end of the construction period, the operating account shall be so kept as to show separately all the expenses of maintenance and operation and other charges incurred and all revenue and income received on account of the Passenger Station,

Equipment Terminal and other separate facilities, respectively, the proper division being made of items of overhead in accordance with such reasonable and equitable methods as may be approved by the Board of Directors. In case any Company is dissatisfied with the division of said items of overhead, it shall have the right to appeal to arbitration, as hereinafter provided.

Rental

The rental for the Passenger Station, Equipment Terminal and other separate facilities, respectively, shall be the total amount required by the Terminal Company to pay the following items:

Interest Charges

(1) The interest charges on bonds, notes, loans and other evidences of indebtedness, except such interest as may be chargeable to Capital Account.

Rents

(2) The total rents assumed by the Terminal Company, arising out of leaseholds, leases, contracts and agreements.

Taxes and Assessments

(3) The taxes, assessments and governmental charges, of every kind, required to be paid by the Terminal Company except such as may be chargeable to Capital Account.

Operation and Maintenance Charges

(4) The net costs and expenses, of every kind whatsoever, required for the operation and maintenance of the Terminal or any part thereof, and which shall include proper charges for reserve for a retirement and replacement provided for in Section 27 hereof. In determining net costs and expense, credit shall be given for moneys received as rentals under Section 33 hereof.

Other Charges

(5) All other costs, charges and expenses, of any and every kind whatsoever, incurred, created or for which the Terminal Company may be in any manner liable, not otherwise provided for, and including expenses necessary in maintaining the corporate organization of the Terminal Company and protecting the rights of its stockholders and bondholders.

Dividends

(6) Annual dividends at the rate of .... per cent (......%) per year on all stock issued by the Terminal Company under the terms of this agreement.

Income

From said total shall be deducted any and all income received by the Terminal Company for special service, receipts from individual companies for repairs or service to equipment, furnishing of supplies or other services, interest on deposits, bills receivable and all other income of any kind whatsoever except net rentals from the Companies hereinafter provided for, and rentals included above in sub-paragraph (4) hereof. The amount thus obtained shall be the total net rental.

Net Rental Apportionment

Section 42. The total net rental for the Passenger Terminal and other facilities shall be divided as hereinafter provided, on a user basis among the Companies.

Property used solely for the convenience of an individual carrier shall be segregated and accounted for separately by the carrier on a fair rental basis.

Payments Before End of Construction Period

(a) The Companies shall pay the Terminal Company the following amounts at or before the end of the construction period.

(1) All amounts, if any, required pursuant to sinking fund provisions, for the retirement of bonds or other obligations of the Terminal Company and required to be paid prior to the end of the construction period.

(2) All amounts payable by the Terminal Company for any other purpose, prior to the end of the construction period, which can not, under the uniform classification of accounts, be capitalized.

Amounts provided for in this Sub-Section (a) shall be paid by the Companies in equal shares, and shall be considered as a part payment on the stock purchased by the said Companies.

Property used jointly or in common for the common interest shall be considered, for the purpose of dividing the net expense to owners or users, as being a joint facility.

Amortization of Indebtedness

(b) [g] The Companies shall pay the Terminal Company in addition to the above rental, from and after the end of the construction period, a sum equal to the amounts required for the retirement of bonds, or other obligations of the Terminal Company, pursuant to sinking fund provisions of any mortgage or other indenture executed by the Terminal Company. The amounts provided for in this Sub-Section (b) shall be apportioned among the Companies on the same basis as the original construction of the Terminal was apportioned and the total amount for which each Company is responsible under the terms of the first sentence of this paragraph Sub-Section (b), shall be calculated, from time to time, and statements furnished to the Companies, whether they are then actually called upon for full payment or not.

(c) In the event of any default by any Company in the payments required by Section 41 and Sub-Sections (a) and (b)| of this Section, if such default continues for .... (........) days, the other Companies shall pay the sums in default apportioned between them, payments under Section 41 being upon a user basis, and said Companies so making said payments shall be subrogated to the rights of the Terminal Company against the defaulting Company.

User Basis Defined—Passenger Terminal

(d) [h] User basis, insofar as the Passenger Station and its facilities is concerned, shall be defined as follows:

Local cars originating or terminating at the Passenger Station shall be counted as one car. Through cars, arriving and departing over the same road in one continuous

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[g] Refer to Section 27. Both Sections 27 and 42 (b) are suggestions to be adopted and adapted as may be required after the plan of finance has been completed.

[h] At terminals where the expense of the Passenger Station and facilities cannot be properly divided by a car count, the following alternate "User Basis" is suggested:

trip shall be counted as .... cars. Cars arriving on one road and departing on another in one continuous trip shall be counted .... cars for each road. A locomotive including tender shall be deemed equivalent to .... cars. Locomotives and empty cars moved between the Passenger Station and Equipment Terminal or other separate facilities shall not be counted.

The total number of cars as thus defined shall be determined each calendar month, and each Company shall pay that proportion of the month's net rental applicable to the Passenger Station which its car count during said month bears to the total car count during said month.

User Basis Defined—Equipment Terminal

User basis, insofar as the Equipment Terminal or other separate facility is concerned, shall be defined as follows:

Each car in train service shall be counted as one car and each locomotive including tender, shall be counted as equivalent to .... cars moving into the Equipment Terminal or other separate facility, and shall be charged to the Company or Companies for whose account it is handled.

It is understood that the above paragraphs in this Sub-Section (d) defining the user basis are not intended to provide for direct charges against any of the Companies for repairs or service to equipment, supplies furnished to train and other items determined in accordance with rules to be prescribed by the Board of Directors of the Terminal Company, which items shall be billed directly against the Company to which furnished. The total number of cars as thus defined shall be determined each calendar month, and each Company shall be called upon to pay that proportion of the month's net rental applicable to the Equipment Terminal which the number of its car count during said month bears to the total car count during the said month.

User Basis Defined

(d) User basis shall be determined by test counts of the proportionate use and cost of use of the various facilities or zones constituting the Terminal, to be made for such facilities or zones at such intervals and for such periods as may be determined by the Board of Directors, the weighted average of such use and costs to be the basis for the monthly rental to be paid by each user until a new count shall have been made.

The test counts shall be on the following basis:

1. Headhouse including Ticket Offices, Waiting Rooms and auxiliary passenger accommodations, on the basis of tickets sold.

2. Baggage, mail and similar facilities, on the basis of the number of pieces or weight handled.

3. Tracks and other facilities in Train Yard, on the basis of cars and locomotives handled.

4. Coach and Cleaning Yard, on the basis of cars handled.

5. Heating, lighting and similar plants and appurtenances to be equitably distributed between the various facilities served.

6. The monthly rental paid under the above five items shall include the total of all of that required to be paid for and in respect to the use of the Passenger Station under Section 41 and Sub-Sections (a) and (b) of this Section.

The use of all Passenger Terminal Facilities may be determined solely by count of cars and locomotives if so determined by the Board of Directors.

Local cars originating or terminating at the Passenger Station shall be counted as one car. Through cars, arriving and departing over the same road in one continuous trip shall be counted as .... cars. Cars arriving on one road and departing on another in one continuous trip shall be counted as .... cars for each road. A locomotive including tender shall be deemed equivalent to .... cars. Locomotives and empty cars moved between the Passenger Station and Equipment Terminal or other separate facilities shall not be counted.

It is understood that the above paragraphs in this Sub-Section (d) defining the user basis are not intended to provide for direct charges against any of the Companies for repairs or service to equipment, supplies furnished to train and other items determined in accordance with rules to be prescribed by the Board of Directors of the Terminal Company, which items shall be billed directly against the Company to which furnished. The total number of cars as thus defined shall be determined each calendar month, and each Company shall pay that proportion of the month's net rental applicable to the Equipment Terminal which the number of its car count during said month bears to the total car count during the said month.

Payment in Legal Tender

All of said payments to be made by the Companies to the Terminal Company shall be made in lawful gold coin of the ...., of the present standard of weight and fineness.

Tentative Monthly Accounting

Section 43. The Terminal Company shall determine, as soon as possible after the first of each month, the net rental for the preceding month and immediately after the closing of each month's accounts, render regular bills collectible against each tenant Company for said Company's proportion of said rental, determined in accordance with the provisions of this agreement. The bills shall be paid promptly as rendered, and any errors developed by an audit of the bills shall be adjusted in the bills during the following months. If the bills are not paid within ten (10) days after receipt thereof, they shall bear interest at the rate of .... per cent (.........%) per annum from the day when due. In case any disagreement arises regarding the amount of the bills and the disagreement cannot be settled within thirty (30) days thereafter, either party may apply for arbitration, in accordance with the provisions hereof, and the decision of the Arbitrator shall be final and binding on all parties concerned.

Inspection of Records

Section 44. The books and accounts of the Terminal Company shall, at all reasonable times, be open to the inspection of the proper officers or agents of each Company and so much of the books and accounts of each of the Companies as affect amounts to be received or paid by the Terminal Company shall, at all reasonable times, be open to the inspection of the proper officers or agents of the Terminal Company.

Auditing Committee Appointed

Section 45. At the beginning of each fiscal year the Board of Directors shall appoint an Auditing Committee of not to exceed three members, to be selected from the chief accounting officers of the Companies, to serve for the fiscal year in which they shall be appointed. It shall be the duty of the Auditing Committee to recommend to the Board of Directors, from time to time, such changes in the form of accounts of the

Terminal Company as the Committee may deem necessary or proper, but all accounting and all such changes proposed shall be in conformity with the accounting rules of the Interstate Commerce Commission from time to time in effect.

Accounting Practices

Section 46. Wherever the phrase "Interstate Commerce Commission" is used in this Agreement with reference to accounting, it shall be construed to mean the existing accounting rules of such Commission or any subsequent modifications thereof, or in the event some other governmental body shall, at any time, have jurisdiction over the accounts of railroad companies then the accounting rules prescribed by such body, and in the event at any time hereafter no governmental body shall have jurisdiction, then accounting rules prescribed by the last governmental body having such jurisdiction.

Interest on Balances

Section 47. Any sum due from any Company, the payment of which is not made at the time fixed herein, shall bear interest at the rate of .... per cent (........%) per annum from maturity until paid.

Article XI

EXTRAORDINARY EXPENSES

Partial Destruction of Property

Section 48. In the event that any major part or parts of the Terminal shall at any time be damaged or destroyed by fire or any other causes, this agreement shall not be terminated and none of the parties hereto shall be released or discharged of any of the covenants or agreements herein to be kept and performed, by reason of such damage or destruction. In the event of the total or partial destruction of any major part or parts of the Terminal, as defined in the By-Laws, by fire or any other causes, its replacement shall be considered as extraordinary expenses, and the same or the equivalent shall be rebuilt or replaced by the Terminal Company with such changes as may be agreed upon between the Companies and the cost thereof, less the amount of insurance received, shall be charged in accordance with the classification of accounts prescribed by the Interstate Commerce Commission. Such portion of the cost thereof as is chargeable to capital account shall be financed by the Terminal Company in the manner hereinbefore provided for in the construction of the Passenger Station, Equipment Terminal and other facilities, or otherwise as may be agreed upon between the Terminal Company and the Companies.

Extraordinary Expenses

The term, "Extraordinary Expenses", as used above, shall be construed to mean any major expenses affecting the total accrued property account, exclusive of land, as that term is limited and/or defined in the By-Laws and work of such magnitude shall not be prosecuted by the Terminal Company until the matter has been presented to the Companies, and acquiescence received from not less than two-thirds of such Companies not then in default.

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ARTICLE XII

VALUATION FOR ACCOUNTING PURPOSES

Valuations

Section 49. For accounting purposes; for pro-rating expenses, particularly in case of any non-owning company as provided for in Section 40 hereof, for special services involving the use of only part of the property; and for other purposes, a valuation shall be made of the property periodically as of December 31st, and brought up to date for each succeeding period. The period in which such valuation shall be used shall be of ten-year intervals, unless changing conditions or ownership shall make it desirable to make such valuation, or any part thereof, at some intermediate period, in the latter case a valuation of such part or all of the property of the Terminal Company shall be made upon vote of two-thirds of the members of the Board of Directors.

Valuation Zones

Section 50. In preparing and making any valuation it shall be assembled by separate facilities, zones and such subdivisions as may be found expedient for the purposes intended and ordered by the Board of Directors.

Amortization or reserve for retirement may be adjusted from time to time, as may appear necessary from the valuations, upon order of the Board of Directors.

ARTICLE XIII

LOSS, DAMAGE, INJURY TO PERSONS

Loss and Damage—Definitions

Section 51. The term, "Terminal Property" wherever used in this Article shall be construed to refer to the sole property of the Terminal Company.

The term, "Loss or Damage", as used in this Article relates to loss or damage arising upon the Terminal Property and embraces all losses and damages growing out of the death of or injury to persons, and loss of or damage to property, and all payments made on account thereof, including amounts paid under any State or Federal compensation law, and also embraces all costs and expenses incidental to any such losses or damages incurred in connection with the construction, reconstruction, repair, renewal, use, operation or maintenance of the Terminal.

Loss and Damage—Liability For

Section 52. Loss or damage occurring upon or adjacent to the Terminal Property shall be borne as between the Terminal Company and the Companies as follows:

(a) When caused by the negligence or wrongful act or omission of the sole employee or employees of one of such Companies, or
(b) By the failure or defect of the exclusive equipment or appliances of one of such Companies, or
(c) By the engines, trains, or cars of one of such Companies without the concurrent negligence or wrongful acts or omissions of any sole employee or employees of any other said Company,

such loss or damage shall be borne by the Company whose sole employee or employees alone or whose exclusive equipment or appliances, or whose engines, trains or cars so caused such loss or damage.

(d) When due to or in any manner growing out of any wreck or other accident in which the engines, trains or cars of one of such Companies are involved, when any such wreck or other accident is caused by failure to construct and/or maintain fences or other enclosures along the right-of-way or by the condition of the tracks, facilities, lands or rights of way, or by unknown causes, or the acts of third persons not in the employ or under the control of any such Company,

such loss or damage shall be borne by the Terminal Company as a part of the operating expense of the Terminal.

(e) When due to the concurring negligence or wrongful acts or omissions of the sole employee or employees of any such Company and of the sole employee or employees of any other such Company or Companies,

such loss or damage shall be borne equally by such Companies, except that each such Company shall bear all such loss or damage in respect to its own exclusive property or property in its custody or upon its cars, and as to its sole employees, passengers, or persons upon its locomotives, cars or trains.

Except as hereinabove in this Section provided all loss or damage happening upon or adjacent to the Terminal Property shall, as between the Terminal Company and the Companies, be borne by the Terminal Company.

Adjusting Claims for Damage

For the purpose of adjusting liability under this Section, the engines, cars and trains in the custody or control and/or being used or operated by any Company shall be deemed the engines, cars, or trains of such Company.

Section 53. The Terminal Company or any Company may make settlement of all claims for loss or damage, for which any of such parties shall be jointly liable hereunder, but no payment in excess of .... (\$.........) except in emergency cases for the settlement of personal injury claims and then not exceeding .... (\$........), shall be voluntarily made by any such Company in settlement of any claim without first having obtained in writing the consent of the other Companies, parties hereto, having an interest in said settlement, and in making voluntary settlements as aforesaid the Company making the same shall in all cases procure from each claimant a written release from liability in the premises.

Reimbursement by Company at Fault

Section 54. The Terminal Company and the Companies agree that whenever loss or damage shall occur which any of them shall be required hereunder to bear, either in whole or in part, the Company or Companies so liable shall, to the extent and in the proportion it or they may be required to bear any such loss or damage, (a) indemnify and save harmless the other Companies from and against suits, actions, causes of actions, claims, demands, attorneys' fees, costs, and other expenses arising from or growing out of any such loss or damage, and (b) upon demand reimburse the other Companies or any of them for any such loss or damage borne by the other Companies or any of them in the first instance; and the Company or Companies so liable shall assume and conduct the defense of any and all suits brought against any of the other Companies on account of any such loss or damage and pay any judgments recovered therein. Provided, however, that any Company or Companies against which any such suit is brought shall give reasonable notice of the institution of any such suit to the Company or Companies required hereunder to bear the loss or damage on account of which any such suit is brought.

ARTICLE XIV

DEFAULT

Default

Section 55. If any Company shall, at any time or times hereafter during the term of this agreement, fail or omit to make the payments or advances herein provided for, or any part thereof, when the same should be paid, as herein provided, or shall fail or omit to keep and perform all covenants and agreements herein contained, or any of them, and shall continue in default in respect of such payments, or the performance of such covenants and agreements, for a period of sixty days, then, and in either and every such case, and as often as any such default shall occur, the Terminal Company may at its option exclude such Company and prevent it from entering upon and using the Terminal or any part thereof during the continuance of such default, and take such other and/or further action for the enforcement of the provisions of this agreement as to it may seem advisable. Provided, however, that any such exclusion or other act of the Terminal Company shall not impair its right of action, or the right of action of the other Companies subrogated thereto, against the Company in default, for the recovery of any and all damages on account of the failure or omission to make such payments or advances, or the non-performance or breach of the terms and covenants of this agreement; but in case of such exclusion or other act as aforesaid, said payments and advances and the several installments thereof, and any other amount or amounts of money to be paid hereunder, which shall have accrued under the terms of this agreement down to the date of said exclusion, shall be deemed and taken to be due and payable, and shall be paid by such Company in the manner hereinbefore provided in this agreement. In the event of such Company being excluded as aforesaid, such Company waives any demand for possession as against it, or any notice of the act of the Terminal Company in declaring the user herein granted at an end.

Payment by Companies Not in Default

In the event of any default by any Company, the other Companies not then in default shall pay, on written request of the Terminal Company to the Terminal Company, any portion or all of such payments due and unpaid by the defaulting Company, apportioned equally among them and shall be subrogated to the rights of the defaulting Company.

No Representation on Board of Directors

No Company in default shall be entitled to or have any representation on the Board of Directors during the time such default exists.

Terminal Company Appointed Attorney

Section 56. Each Company has made, constituted and appointed, and hereby makes, constitutes and appoints, the Terminal Company its true and lawful attorney, for it and in its name, place and stead, with full power and authority (but to be exercised only in the event of its default) to pay out any or all of its funds in the possession of the Terminal Company, first, to the Terminal Company, on account of its indebtedness or proportion of the total indebtedness to the Terminal Company, and, second, to the other Companies, on account of any indebtedness to them relating to the Terminal, or the use thereof, hereby ratifying and confirming all that its said attorney may do by virtue of this provision.

Notice to Companies

Section 57. In the event that any Company or Companies shall be in default under the provisions of this Article, the Terminal Company shall immediately notify the Company or Companies not in default that such default has occurred, and shall, in addition to any other action determined by its Board of Directors, take such action authorized hereunder in respect to the Company or Companies in default as may be requested by the Company or Companies not in default.

Breach of Covenant

Section 58. The Terminal Company may restrain any threatened breach of any covenant in this agreement contained, and, in spite of any other action in excluding a defaulting Company or Companies, may, after such exclusion, bring suit against such defaulting Company or Companies for damages for the breach of this agreement. The rights and remedies of the Terminal Company under this agreement are cumulative, and the exercise of one right or remedy shall not be deemed to exclude the exercise of any other right or remedy provided for in this agreement or allowed by law, and the Terminal Company may proceed to exercise any proper remedies successively or contemporaneously, one with another, without prejudice to any one of the Terminal Company's other rights so accruing. Consent to any act or acts which would otherwise be a violation, shall not, nor shall waiver of all redress for any violation or violations either of covenant or condition, prevent a subsequent act, which would otherwise have constituted a violation, from having all the force and effect of an original violation.

Article XV

ASSIGNMENT OF RIGHTS

Assignment of Rights

Section 59. No assignment by any Company of any interest or right under this agreement, separate and apart from an assignment, sale or lease of its entire property, shall be valid without the written consent of the Terminal Company and of each of the Companies not then in default; and no assignment, whether in connection with the sale of the assigning Company's railway and other property, or otherwise, shall release such assigning Company from any of its obligations under this agreement accrued to date of such assignment. If any Company shall purchase the railway of any other Company, or if any of the Companies shall be consolidated, the purchasing Company, or the consolidated Companies, shall be liable to make all payments and to perform all obligations that would have been obligatory upon each of such Companies had such purchase or consolidation not been made.

Article XVI

MISCELLANEOUS

Severalty Responsibility

Section 60. All of the covenants and agreements to be performed by the Companies hereunder are several and not joint and in no event shall any of the Companies be liable for any default of any of the other Companies except as herein expressly provided.

Service of Notice or Demand

Section 61. Any notice to or demand upon any Company, party hereto, under this agreement may be given by mailing the same correctly addressed, with postage prepaid, to such Company as follows: A Company ...., B Company ...., C Company ...., Terminal Company ...., unless such Company shall have given previous notice in writing to the Terminal Company designating some other address to which such notices and demand shall be mailed, in which case such notices and demand shall be deemed duly served upon the Company to which the same was addressed .... (......) days after the date when the same was mailed, whether or not such notice was actually received, and no further notice shall be required.

No Special Rights or Privileges

Section 62. So long as this agreement shall continue in force and effect between any or all of the Companies, none of the said Companies shall claim or be entitled to any special rights or privileges not covered by the terms of this agreement and which are not available to all of the Companies. Each of the Companies hereby waives any right, privilege, or advantage in connection with any property of the Terminal Company, use of the same or in connection with any service therewith which is not enjoyed or cannot be extended in common to all of the Companies and none of the Companies shall be subject to any disadvantages, restrictions in service, charges or burdens other than or different from those to which all other Companies are subjected unless expressly stipulated in this agreement or granted to such Company or Companies by lease made under the provisions of Section 33 hereof.

Article XVII

ARBITRATION

Appointment of Arbitrator

Section 63. In case any question arises under this agreement or concerning the subject-matter thereof, upon which the parties hereto cannot agree, such question may be settled by a sole, disinterested arbitrator, to be selected jointly by the parties to this agreement, and if they fail to select such arbitrator within .... (......) days after demand for arbitration is made by any party hereto, then such arbitrator shall be appointed by the judge of the .... Court of ....

Cost of Arbitration

The expense of arbitration shall be apportioned between the parties hereto, or wholly borne by either party, as shall be determined by the arbitrator.

Article XVIII

TERMINATION

Term of Agreement

Section 64. This agreement shall continue for the term of .... (......) years from the date hereof, and unless terminated by written notice served upon the Terminal Company by one or more of the Companies at least .... (......) years before the expiration of said term of .... (......) years it shall continue in force for the renewal term of .... (......) years, and shall continue

in force after such renewal term unless and until terminated by written notice served on the Terminal Company and the other Companies by any Company not less than .... (......) years before the date on which it is desired to terminate, in which event this agreement shall terminate as to all the parties hereto.

Federal and State Laws to Control

Section 65. This agreement is made subject to all Federal and State laws and all rules or orders made by any public board, commission or body of competent jurisdiction, and this agreement shall not be modified or amended without the consent in writing of all the Companies not then in default, unless it shall be found to be in conflict with any such law, rule, or order existing from time to time, in which event it shall be modified to conform thereto.

Successors and Assigns

Section 66. All the covenants, conditions and undertakings herein contained shall extend to and be binding upon and inure to the benefit of the respective successors, lessees and assigns and other successors in title or interest of the parties hereto.

Titles of Articles and Sections

Section 67. All titles of Articles and Sections printed in boldface type are inserted for purposes of convenience only, and shall not be considered a part of this agreement, nor be used in any manner as an aid to the interpretation thereof.

In Witness Whereof, the parties hereto have caused this agreement to be signed in .... by their duly authorized officers and their respective corporate seals to be hereunto affixed and duly attested by their respective Secretaries or Assistant Secretaries, the day and year first above written.

Attest:	The ....Terminal Company
..........................Secretary	By ....
Attest:	"A" ....Railway Company
..........................Secretary	By ....
Attest:	"B" ....Railway Company
..........................Secretary	By ....
Attest:	"C" ....Railway Company
..........................Secretary	By ....

Appendix D

(4) FORM OF CONVEYANCE OF TITLE GRANTING THE RIGHT TO CONSTRUCT AND MAINTAIN AIR-RIGHT BUILDINGS OVER RAILWAY PROPERTY

O. K. Morgan, Chairman, Sub-Committee; Calvin Bartlett, R. P. Eubank, J. S. Lillie, Huntington Smith.

Your Committee charged with the preparation of a form as above, made inquiry of the Committee on Outline of Work and was advised to first prepare a Form of Deed covering a fee simple conveyance rather than a Form of long-term lease.

We report progress as follows:

The field has been canvassed to ascertain past usage and to secure copies of conveyances of air-rights, both deeds and leases. We find the present use of air-rights limited to a few of the larger cities. Comparatively few conveyances by deed are of record—a much greater number of long-term leases are to be found. The prospects appear to be that the number of air-right conveyances will increase rapidly in the future.

As information for the membership of the Association the Committee has prepared a general statement relative to Air-Rights which it offers for publication in the Proceedings, and recommends that the subject be continued.

AIR-RIGHTS

Every owner of a boundary of land has the control and use of:

A—the surface.
B—the earth to the center thereof.
C—the air extending upward as far as he may desire to use it.

Consequently said owner may sell either B or C and retain the use of A subject to certain rights of access to B or C. Hence we may define "Air-Rights" as herein understood as the conveyance of rights to own and use C as distinct from A or B.

While the ownership of Air as such is probably not capable of absolute ownership distinct from access for use, it is capable of ownership by occupancy and it is certain that in all cases where the conveyance attaches some increment of the use of the surface, the title is valid as any other realty conveyance and such practical considerations as foundations and columns to support structures in the air provide the attachment to the surface considered as a requisite to make valid the ownership of the air. The purchaser of "Air-rights", therefore, buys property extending as far upward as he desires to use it without any question of its validity in law.

Our great cities where space is becoming ever more precious offer the choicest fields for the transfer of air-rights. In many cases the existence of railway tracks and facilities present a barrier to the expansion of high value business areas and force development in other unnatural directions. Within the past few years there has come into being a method of overcoming these railway barriers by the conveyance of air-rights over railway tracks. This process promises to expand rapidly in the future when real estate men fully comprehend the railways can and will dispose of air-rights and that railway barriers are not insuperable obstacles.

Already air-rights are in extensive use in New York and a few such rights have been sold and used in Chicago and perhaps in some other cities. While the operation of trains by steam power imposes some extra difficulties in caring for the smoke nuisance

this difficulty has been, and can in most cases be, overcome, so air-rights are not necessarily confined to areas where trains are operated by electrical energy. However, electrical operation simplifies the construction features for both parties.

Furthermore, air-rights tend to distribute the economic burden of use of high value land by dividing the cost between the railway on one hand and the air-right owner on the other hand, both as to taxes and rent. This factor will probably encourage the greater use of air-rights over railway property in the future. Another factor is that relatively large areas may be secured for air-rights over railways by a single transaction; whereas the acquisition of an equally large area in a high value district is usually beset with a greater expenditure, difficulty and loss of time, due to the area being divided and owned or under lease to a multiplicity of persons and usually encumbered by structures which must be wrecked and removed prior to beginning work on the new structure.

The method of appropriating air-rights over railway lands depends upon the character of the railway's ownership of the land, as well as the provisions of any mortgage thereon and the laws of the State where located. Where the railway owns only an easement and not the fee probably all it can convey is a lease. Where it owns in fee simple it can probably make a warranty deed. Where it owns only for "railway purposes" or for "railway uses", such limitation may prevent disposal of air-rights. In any event the legality of a conveyance either by deed or lease and the release of any mortgage encumbrance to clear the title is a matter to be handled by the railway's legal department. Any purchaser of air-rights with accompanying foundation and support rights will generally require release from legal encumbrances of title to save handicapping his financing of the enterprise.

Air-right conveyances are made both by warranty deed and by lease. In New York City leases are most common and no information covering a sale has been obtained. In Chicago several substantial sales are of record. Transfer of air-rights at other points have come to the Committee's attention, but they are not over railway tracks.

The values involved in air-right transactions are usually substantial and are, of course, predicated on the value of the land itself. The purchaser's investment is less than for similar unencumbered land and his loss of rental value by reason of the railway occupancy of the least rentable space is usually small in comparison to the total rental value of the structure. The accessibility to railway facilities may in fact be an advantage to the purchaser and the enterprise.

Considering only fee simple conveyances of air-rights by warranty deed, two methods have been used to describe the property conveyed. The difference between the two methods is of sufficient importance to demand attention.

The first method may be termed three-dimensional since it provides a very definite description of the land property and space conveyed by three separate descriptions, i.e.

(1) The air lot, or all space above a certain level or plane by metes and bounds.
(2) The cylindrical or rectangular prism shaped spaces occupied by the columns between two fixed levels or planes.
(3) The prisms of space occupied by the foundations below a fixed level or plane.

Suitable plans accompany this description which delineate the shape and location of each space and these plans are made a part of the deed.

This provides a definite and rigid description, usually of considerable length. Provision is made in the deed for rights of entry for construction, maintenance and renewal.

The second method may be termed the reservation method. By it the entire property is described and conveyed preserving therefrom a certain "excepted space" for the use of the railway below a certain level. Within the excepted space the columns and

foundations are permitted to occupy a part thereof at points not interfering with the railway tracks or other facilities.

This second method provides a flexibility not inherent in the first method. By it the location of columns and tracks, the size and shapes of foundations can be adjusted to the varying needs of the parties. Since no one knows what the future may develop as to types of buildings or structures, location of columns or foundations, or tracks, some flexibility appears desirable in order that future changes can be made without a new deed. It also provides a simpler description and a more compact document.

In the transfer of air-rights, where two separate parties occupy separate layers of the same boundary it is to be expected many mutual covenants will be agreed upon and set forth in the document recording them. Each particular situation is liable to impose its own special requirements in addition to a set of general covenants apt to be common to all such documents, whether deed or lease.

The matter set forth in this article has been collected in connection with, and is presented as introductory general information pertaining to, air-right transactions for the benefit of the membership of the American Railway Engineering Association. Said Association, through its officials, has assigned to its Committee on Uniform General Contract Forms the preparation of a standard Form of Deed for the Conveyance of Air-Right Structures over Railway Property. Such a form will, in due course, be submitted for consideration by the Association.

Appendix E

(5) FORM OF AGREEMENT FOR PIPE LINE CROSSINGS UNDER RAILWAY TRACKS, COLLABORATING WITH COMMITTEE XIII—WATER SERVICE AND SANITATION

Charles Silliman, Chairman, Sub-Committee; C. Frank Allen, F. H. Fechtig, B. Herman, C. B. Niehaus.

Your Committee has collected from representative carriers in different parts of the country copies of the forms used by them for pipe line crossings. After a study of these contract forms which differ by reason of the carriers' different locations, the Committee has prepared a tentative general form. This has been considered at two meetings of Committee XX.

The tentative draft has been submitted to Committee XIII with whom we are to collaborate and contact has been made with the American Petroleum Institute whose views and needs we are instructed are to be considered in this connection.

Until the coöperative work is further advanced, your Committee is not prepared to submit its final recommendations. It therefore requests that this statement be received as a report of progress.

It is recommended that the subject be continued.

REPORT OF COMMITTEE XV—IRON AND STEEL STRUCTURES

A. R. Wilson, *Chairman;*
P. S. Baker,
J. E. Bernhardt,
A. J. Buhler,
A. W. Carpenter,
O. F. Dalstrom,
R. P. Davis,
F. O. Dufour,
Thos. Earle,
S. Hardesty,
C. S. Heritage,
O. E. Hovey,
J. B. Hunley,
Jonathan Jones,
M. S. Ketchum,
W. S. Lacher,
P. G. Lang, Jr.
B. R. Leffler,
H. S. Loeffler,
C. H. Mercer,
G. A. Haggander, *Vice-Chairman;*
P. B. Motley,
Albert Reichmann,
H. N. Rodenbaugh,
O. E. Selby,
I. L. Simmons,
W. A. Slater, (*)
C. E. Sloan,
S. M. Smith,
P. B. Spencer,
H. B. Stuart,
R. M. Stubbs, (†)
G. H. Tinker,
G. H. Trout,
F. E. Turneaure,
F. P. Turner,
R. A. Van Ness,
H. T. Welty,
W. M. Wilson,

Committee.

(*) Died October 5, 1931. (†) Died April 19, 1931.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A). It is recommended that the report be received as information.

(7) Use of copper-bearing steel for structural purposes (Appendix B). It is recommended that the conclusion in the report be approved for publication in the Manual.

Respectfully submitted,
The Committee on Iron and Steel Structures,
A. R. Wilson, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

I. L. Simmons, Chairman, Sub-Committee; J. E. Bernhardt, O. F. Dalstrom, B. R. Leffler, P. B. Motley, O. E. Selby.

Under the direction of this Committee, General Specifications for Steel Railway Bridges, Fourth Edition, was issued under date of May, 1931. This edition included all revisions adopted by the Association to the date of issue.

In accordance with plans of the Board of Direction, an index covering the work of Committee XV has been completed and submitted to the Secretary of the Association.

Bulletin 340, October, 1931.

Appendix B

(7) COPPER-BEARING STEEL FOR STRUCTURAL PURPOSES

F. P. Turner, Chairman, Sub-Committee; P. S. Baker, A. W. Carpenter, Thos. Earle, W. S. Lacher, C. H. Mercer, C. E. Sloan, G. H. Trout, H. S. Loeffler, R. A. VanNess.

This Committee makes the following report and recommends that the conclusions be approved for publication in the Manual:

The report of this Sub-Committee, as shown upon page 1015, of A.R.E.A. Bulletin 314, February, 1929, contains the most conclusive information of record on the value of copper-bearing steel as determined from service tests. This relates to its use and service in tie plates and freight cars. Reference is also made to information on this subject, as printed in A.R.E.A. Bulletin 322, December, 1929, pages 974 and 975, and in Bulletin 330, October, 1930, page 126.

Information recently collected from some of the large manufacturers of steel indicates a continued demand for copper-bearing steel for structural purposes, and the production of a substantial tonnage during the year 1930. Reports received also show that five of the largest eastern railroad systems are specifying copper-bearing steel for many railway bridges, and that certain cities and counties specify copper-bearing steel for highway bridges.

Conclusions

From results of exposure and service tests, on the use of copper-bearing steel, we recognize its value as a rust-resisting metal, and recommend its use in railway steel structures exposed to corrosive influences.

REPORT OF SPECIAL COMMITTEE ON CLEARANCES

A. R. Wilson, Iron and Steel Structures *(Chairman)*;
J. E. Armstrong, Assistant Chief Engineer, Canadian Pacific Railway (representing Canadian Practice);
H. Austill, Wooden Bridges and Trestles;
C. W. Baldridge, Roadway;
R. C. Bardwell, Water Service and Sanitation;
E. H. Barnhart, Rules and Organization;
H. M. Bassett, Electricity;
J. G. Brennan, Grade Crossings;
P. M. Gault, Signals and Interlocking;
C. R. Harding, Track;
M. Hirschthal, Masonry;
L. P. Kimball, Shops and Locomotive Terminals;
H. L. Ripley, Yards and Terminals;
A. L. Sparks, Buildings;

Committee.

To the American Railway Engineering Association:

Your Committee respectfully submits the following as its report.

Clearance diagrams for Platforms (Fig. 4 and 5).

These diagrams continue the series that this Committee will present from time to time, supplementing Fig. 1, 2 and 3, and Paragraphs (a), (b), (c), (d) and (e), which were presented to and adopted by the Association March, 1931 (Bulletin 337, July, 1931, Revisions and Additions to the Manual, p. 109).

Action Recommended

That the clearance diagrams, Fig. 4 and 5, be approved, and the revisions substituted for the present recommendation in the Manual, and that paragraphs (a), (b), (c) and (d) (Bulletin 337, July, 1931—Revisions and Additions to the Manual, p. 109) shall also apply to Fig. 4 and 5.

Respectfully submitted,

The Special Committee on Clearances,

A. R. Wilson, *Chairman.*

Bulletin 340, October, 1931.

CLEARANCE DIAGRAMS FOR PLATFORMS

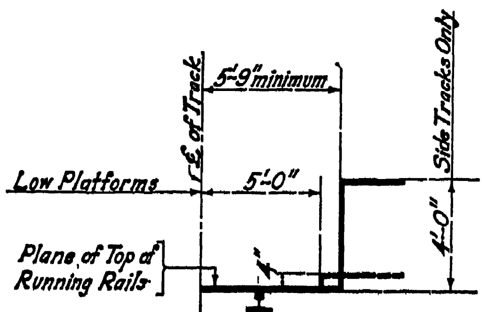


FIG. 4

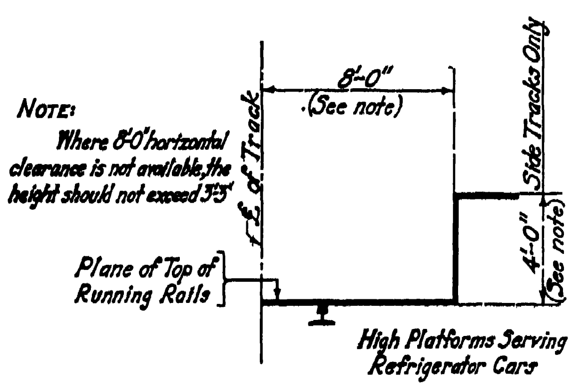


FIG. 5

REPORT OF COMMITTEE XVIII—ELECTRICITY

SIDNEY WITHINGTON, *Chairman;*
B. F. BARDO,
H. M. BASSETT,
L. S. BILLAU,
D. J. BRUMLEY,
H. A. CURRIE,
J. C. DAVIDSON,
J. H. DAVIS,
H. L. ETHERIDGE,
J. S. HAGAN,
S. W. LAW,
PAUL LEBENBAUM,
W. P. MONROE,
J. V. B. DUER, *Vice-Chairman;*
W. L. MORSE,
R. J. NEEDHAM,
E. H. OLSON,
J. A. PEABODY,
H. W. PINKERTON,
J. T. SEAVER,
W. M. VANDERSLUIS,
L. S. WELLS,
L. C. WINSHIP,
C. G. WINSLOW,
R. P. WINTON,
G. I. WRIGHT,

Committee.

To the American Railway Engineering Association:

Following the precedent of the preceding year, your Committee on Electricity refers to the detailed reports made to the Electrical Section and reprinted in Bulletin 338, August, 1931.

As a matter of record, a synopsis of the reports is given below:

2. Inductive Co-Ordination

Co-operation has been continued with the two Joint General Committees on Inductive Co-ordination of the American Railway Association and the National Electric Light Association, and the American Railway Association and the Bell System. Work is progressing on the formulation of "principles and practices."

3. Power Supply

An exhaustive report was presented on (a) steam power available for traction and general power purposes; (b) water power available for traction and general power purposes; (c) internal combustion engine power supply. The report also contained interesting statistics on Electric Energy purchased and manufactured by steam railroads, and capacity of generators installed in public utility power plants in the United States.

4. Electrolysis

The study of electrolysis with the view of including description of measures taken to mitigate electrolysis in connection with the Cleveland Union Terminal and the D. L. & W. electrifications has been continued, and report is made on the steps taken at the Cleveland Union Terminal electrification.

5. Co-operation in Miscellaneous Regulations

The negotiations with the National Electric Light Association in the preparation of "principles and practices" for power wire crossings over railroads; with accompanying specifications, have been continued. Also, the formulation of "principles and practices" concerning crossings between railway lines and electric power lines.

6. Overhead Transmission Line and Catenary Construction

The Committee has considered the preparation of typical pole line construction diagrams with a view to standardization, but has postponed action. Tentative specifications for copper and bronze trolley wire have been submitted as information.

Bulletin 340, October, 1931.

7. Economics of Railway Location as Affected by Electric Operation

Reference is made to a report of a concrete example to illustrate the application of a theory regarding the selection of electric switching locomotives, prepared by Committee XVI of the Construction and Maintenance Section.

8. Standardization of Insulating Tape

Specifications for Black Varnished Cloth Tape—Straight and Bias Cut, were presented.

9. Standardization of Insulators

The Committee has kept in touch with developments in connection with Specifications for Porcelain Insulators for Railroad Supply Lines, but no changes are proposed at this time.

10. Protection of Oil Sidings from Danger Due to Stray Currents

The Rules with above title have been superseded by "Recommended Practice for the Protection of Tracks Used in the Loading or Unloading of Inflammable Liquids from Danger of Fire Caused by Electric Sparks."

11. Specifications for Track and Third-Rail Bonds

Proposed specifications for Stud Terminal Copper Rail Bonds are presented. Study has also been given to the contact areas and resistances of welded bonds.

12. Illumination

The Incandescent Lamp Standards have been revised and amplified. Floodlighting of railroad yards is reported on and Specifications for Large Tungsten Filament Incandescent Lamps submitted.

13. Design of Indoor and Outdoor Substations

Under this heading, report is made on (a) substation insulation; (b) working clearances; (c) relay protection.

14. High Tension Cables

Progress is reported on the preparation of Specifications for High Tension Cables.

15. Application of Corrosion-Resisting Materials to Railroad Electrical Construction

The samples for corrosion tests installed at Cedar Hill Enginehouse, New Haven, have been under observation and report on their behavior will be made later. Additional samples have been installed in Hemphill Tunnel and are to be installed in Lambert's Point Pier on the Norfolk & Western in the near future.

16. Form of Power Contract for Large Blocks of Power

Progress is reported on the collaboration with Committee XX of the Construction and Maintenance Section in the preparation of a "Form of Agreement for the Purchase of Electrical Energy in Large Volume."

Action Recommended

1. That the report of the Committee on Electricity be accepted as information.

Respectfully submitted,

THE COMMITTEE ON ELECTRICITY,
SIDNEY WITHINGTON, *Chairman.*

REPORT OF COMMITTEE XIV—YARDS AND TERMINALS

H. L. Ripley, *Chairman;*
J. R. W. Ambrose,
Irving Anderson,
C. E. Armstrong,
J. E. Armstrong,
C. J. Astrue,
Wm. Atwill,
H. M. Bassett,
E. J. Beugler,
C. H. Blackman,
Alfred Bousfield,
N. C. L. Brown,
H. F. Burch,
W. A. Christian,
W. F. Cummings,
A. W. Epright,
E. H. Fritch,
W. H. Giles,
E. D. Gordon,
R. J. Hammond,
G. F. Hand,
J. V. Hanna,
E. M. Hastings,
M. J. J. Harrison, *Vice-Chairman;*
H. O. Hem,
W. H. Hobbs,
C. T. Jackson,
E. T. Johnston,
E. K. Lawrence,
J. L. Loida,
L. L. Lyford,
C. P. McCausland,
C. H. Mottier,
A. E. Owen,
H. J. Pfeifer,
T. R. Ratcliff,
H. M. Roeser,
W. B. Rudd,
W. C. Sadler,
C. U. Smith,
E. E. R. Tratman,
H. L. Vandament,
A. P. Wenzell,
J. L. Wilkes,
W. M. Wilson,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents report covering the following subjects:

(1) Revision of Manual (Appendix A). It is recommended that the revisions outlined be approved for publication in the Manual.

(2) Produce Terminals (Appendix B). It is recommended that the report be accepted as information and the subject continued.

(4) Provisions for parking and garage facilities for private automobiles of railway passengers at passenger terminals and way stations (Appendix C). It is recommended that the report be received as information and that the subject be held in abeyance for a year.

(6) Hump Yards (Appendix D). It is recommended that the report be received as information and the subject continued.

(7) Co-ordination of rail and water terminals (Appendix E). It is recommended that the report be received as information and the subject continued.

(9) Scales used in railway service: Track scale test weight cars (Appendix F); Bearing value of pivots for scales (Appendix G). It is recommended that the two reports on track scale test weight cars and bearing values of pivots for scales be received as information and the subject of scales used in railway service be continued.

(10) Bibliography on subjects pertaining to yards and terminals appearing in current periodicals (Appendix H). It is recommended that this data be received as information and the subject continued.

Progress is reported on Subjects (3) Effect of motor coach and motor truck service on design of way and terminal station facilities; (5) Clearances; (6) Air ports.

Respectfully submitted,

The Committee on Yards and Terminals,
H. L. Ripley, *Chairman.*

Bulletin 340, October, 1931.

Appendix A

(1) REVISION OF MANUAL

H. L. Ripley, Chairman; M. J. J. Harrison, Vice-Chairman, Sub-Committee; Irving Anderson, J. E. Armstrong, H. M. Bassett, E. J. Beugler, H. F. Burch, E. H. Fritch, R. J. Hammond, E. T. Johnston, C. U. Smith, E. E. R. Tratman and J. L. Wilkes.

Refer to the 1929 Manual: Under the caption "Freight Yards—General", at page 997, following paragraph 9, insert:

To meet traffic requirements a yard should be able, even in peak periods, to receive trains promptly upon arrival, perform any auxiliary service (such as icing, feeding and watering stock, making running repairs, etc.), switch cars into their proper classifications without appreciable delay, and dispatch these cars in their proper position in the designated outgoing trains in a minimum of time.

At page 1000, in place of paragraph 47, substitute:

Ice house, stock pens, L. C. L. transfer, etc., should be so located that cars may be placed with minimum delay after arrival and be readily accessible for switching or placement in outbound trains.

Same page, following paragraph 50, insert a heading as follows:

Hump Yards

Then insert:

When the volume of traffic or other conditions justify a hump yard to meet the requirements (see Vol. 30, page 762; Vol. 31, page 1014 and Vol. 32, page 693) the yard layout should provide for a continuous movement of a draft of cars over the hump once it has been started, for the movement of the cars of the draft to their proper position on the different classification tracks without damaging impacts, and for a minimum loss of time between humping successive drafts. Such a layout will result in the nearest possible approach to continuous humping.

The Design must include the track layout and gradients of all parts of the terminal affecting economical and efficient operation of the hump. To care properly for local conditions each terminal must be studied independently.

The Track Arrangement between the receiving tracks and the hump should provide not only for the release of road locomotives from the receiving tracks with minimum interference with hump operations, but also for moving cars to a point close to the crest of the hump while other cars are being humped, as well as permitting the quick return of the humping engine to the receiving tracks.

If the classification tracks are also used as departure tracks, it is desirable to provide additional classification tracks for overflow classification space during the inspection and preparation time of a departing train. Lead tracks of sufficient lengths should be provided at the outgoing end so that any doubling may be done without fouling the entering end of the classification tracks and thus interfering with hump operations.

The Hump Master's Cabin, hump signal control and other communication facilities should be located at the crest of the hump on the right hand side, as cars should be uncoupled from the right hand side so that the forward knuckle will be open as the impact of normal coupling will often close the rear knuckle."

Follow this with the heading:

Hump Yards with Car Riders

and insert the material now appearing in the Manual under that heading.

Follow the above (after the typical "Cut List") by inserting the heading

Hump Yards with Retarders

and add:

The Classification Tracks generally should be divided into groups of from four to eight tracks, each group served by a sub- or group, lead. The hump leads and the group leads should be designed to direct the cars quickly into diverging routes with a minimum distance between the crest of the hump and most distant clearance point. Lap switches and short turnouts are of desirable assistance in obtaining this minimum.

Two basic operating conditions should be considered in designing the gradients of a classification yard.

(a) The heavy easy rolling car moving under the most favorable running conditions (hot weather, following wind, etc.).

(b) The light hard rolling car moving under the least favorable running conditions (cold weather, adverse wind, etc.).

Sufficient difference in elevation, or drop, must be provided from the crest of the hump to the clearance point of any classification track to ensure that the hard rolling car under adverse conditions will roll at least into clear on its classification track; however, it is fundamental that cars shall not accelerate unduly after leaving the last retarder, if damaging impacts are to be avoided. Hence the gradients that should be provided below the last retarder must be such as will result in little, if any, acceleration of the easy rolling car under favorable conditions.

Thus, the drop from the crest of the hump to the end of the last retarder should be 'A' minus 'B', where:

(A) is the drop required between the crest of the hump and clearance point based on the hard rolling car under adverse conditions.

(B) is the drop required from the end of the last retarder to clearance point based on the easy rolling car under favorable conditions.

This drop—between the crest of the hump and the last retarder—should be so apportioned that:

(a) The hump gradients will quickly separate the cars or cuts to provide the spacing necessary for the free throwing of switches.

(b) The gradients through the last retarder are sufficient to start an average rolling car which has been stopped in the last retarder.

Where a scale or scales are installed on the hump, and/or two tracks are built over the hump with double crossovers, the distance from the crest of the hump to the clearance points of the classification tracks will be materially increased. This will result in increased height of the crest of the hump to provide enough drop for the light hard rolling cars under adverse conditions and this will necessitate additional retarding capacity to provide for the heavy easy rolling cars under favorable conditions. The increased height of hump will also mean increase in cost of constructing the yard and in cost of operation.

"Retarder towers should be located so that operators will have a clear view at all times of the cars they are controlling.

"The control of switches and retarders should be distributed among the towers so that the work will be evenly apportioned among the operators, so far as practicable.

"Loud speaker telephone circuits between the hump and each retarder tower are essential.

"Pneumatic tubes between the general yard office and strategic points will reduce time in handling waybills, inspection lists, etc.

"Teletype machines or pneumatic tubes between the yard office, the hump cabin and retarder towers, will permit handling cut lists promptly.

"Adequate yard lighting is always desirable, but is particularly necessary for the safe operation of a hump yard with retarders. It is essential that the visibility be particularly good in the retarder zone. Supplementary lights, if necessary, should be provided so that the retarder operators may check the numbers and initials of cars passing their towers.

"Hot oil applied to the car wheel journals during cold weather will decrease journal box resistances, thus minimizing the difference between winter and summer car resistances. Hose outlets with drip connections should be located on each side of the hump track two or three car lengths in advance of the crest of the hump. The oil should be applied to the journals under pressure and at a temperature of not less than 180 degrees Fahrenheit.

"Flange oilers have a marked effect on car resistance, both in lowering the total resistance encountered and in decreasing the spread between resistances in the action of individual cars. Moreover, it introduces a valuable element of flexibility available to overcome in part the higher resistances encountered in winter weather."

Appendix B

(2) PRODUCE TERMINALS

E. T. Johnston, Chairman, Sub-Committee; H. L. Ripley, M. J. J. Harrison, J. R. W. Ambrose, E. J. Beugler, C. H. Blackman, H. F. Burch, W. F. Cummings, E. H. Fritch, W. H. Giles, R. J. Hammond, G. F. Hand, John V. Hanna, E. M. Hastings, W. H. Hobbs, E. K. Lawrence, L. L. Lyford, C. H. Mottier, H. J. Pfeifer, W. C. Sadler, C. U. Smith, E. R. R. Tratman, A. P. Wenzell.

The object of produce terminals is to expedite, concentrate and segregate delivery of perishable farm products, such as fruits, vegetables and, in some cases, butter, eggs and poultry. Design of these facilities varies materially from the design of freight houses and team yards handling non-perishable freight.

The business is seasonable for various commodities and for the same commodities from different producing sections. It is highly desirable that the time of making deliveries be reduced to the absolute minimum and the commodities removed from buildings or cars as soon as possible. Most terminals have rigid rules setting forth definite periods for display, sale and removal of commodities from auction and sales buildings. These rules benefit all concerned. They promote early delivery to retail stores, enable a jobber to purchase with the assurance that prices will not be lowered a few hours after purchase, release the facilities for the next day's business and reduce the amount of produce spoiled by waiting too long for a favorable price.

Produce terminals, therefore, must be considerably larger than similar facilities for handling non-perishable freight. Traffic during peak periods must obviously be handled without delay and each day's traffic handled during a relatively short portion of the day.

From the standpoint of general economy, union terminals are favored, serving the entire trade of a community and served by all railroads, directly if possible or under equitable switching arrangements. This conclusion may be modified in very large metropolitan areas, such as New York and Chicago. Where two or more terminals are located in a city of average size, it is usually found that one terminal does practically all the business. In the limited time allowed between opening auction or private sales buildings to the jobbers and the closing time for sales, the jobbers naturally wish to inspect and compare quality and price of all produce reaching the market. From a railroad standpoint, joint operation is usually cheaper and the first investment considerably less, as the joint terminal can take care of the various peaks of commodities shipped from different regions as mentioned above. For example, the peak of Far Western produce traffic is in the late summer and early fall, while the Southern produce traffic is heaviest during the spring and early summer.

General Type

In general, a produce terminal usually includes a team yard and building for display, sale and storage of produce, together with the necessary trackage. In further detail, a produce terminal may have any or all of the following facilities:

1. Receiving yard.
2. Inspection and hold yard.
3. Team yard.
4. Buildings divided into separate stores with or without direct track service.
5. Buildings for display and private sale.
6. Buildings for display and auction.
7. Auction rooms.
8. Offices.
9. Cold storage warehouse.
10. Icing facilities.
11. Incinerator.
12. A farmers' market.
13. A track system serving the yards and buildings.

The type and extent of facilities to be provided depend on local conditions and methods of handling traffic and should be developed by conference with the dealers, who usually have local associations for handling general matters pertaining to the trade. The establishment of a new central terminal will often result in changing the methods in effect. Terminals now in operation provide for the following methods of handling produce:

1. Direct carload delivery from cars on team tracks after inspection, which includes diversion of cars from the terminal to other points.

2. Lot sales from cars on team tracks either direct or over platforms. This method is usually employed in handling juice grapes, watermelons, etc.

3. Lot sales from cars on team tracks after inspection of samples in stores near the team yard.

4. Carload delivery to a store or group of stores with direct track service.

5. Carload delivery to auction and private sale buildings with direct track service.

As an example of method No. 5, cars are ordered to the house prior to a definite cut-off time in the afternoon or evening, either from hold tracks or from trains which will arrive during the evening. Cars are placed and unloaded during the night. Prospective buyers are admitted to the display shed early in the morning for a brief inspection of the produce, after which the auction is held or private sales started. Produce sold to jobbers is usually delivered to the tail board of their trucks and the house is cleared as far as possible by noon or shortly thereafter. This affords an opportunity for cleaning the house thoroughly in advance of the following day's business.

Where there is direct track service to buildings, cars are usually placed at night and unloaded and removed as soon as possible in order that trucks may use the platform for loading produce during the early morning hours and, to a lesser extent, throughout the day.

There are several very important pier stations in Manhattan. These differ from inland terminals in that cars are delivered to them on car floats and unloaded over a trucking platform on the middle of the float, and that delivery to trucks is much more difficult since the piers are surrounded by water on three sides and the only trucking space is at the shore end of the pier and on the pier itself. Otherwise, the requirements are quite similar to a building for display and auction.

Location

Primarily, the location should be convenient for the dealers, with easy access over wide and well improved highways, and with relatively short hauls to distributing points. Congested areas should be avoided. The location selected should, of course, be such that connections may be made to the railroad or railroads serving the terminal which will allow quick delivery from road trains. This is quite important from the standpoint of road schedules. A location near a terminal yard is usually advantageous. The cost of available land, with reasonable provision for expansion, is also a factor.

With the general use of motor trucks, it is by no means essential that the terminal be located in the business district of a city. In several instances successful terminals have been built (with the consent of the trade) a considerable distance from the former center of the produce trade, in order to avoid delays incident to congestion and to improve railroad service.

The location will, of course, have to conform with local zoning ordinances unless such ordinances can be modified in the particular case.

Buildings

In the design of auction and private sales buildings, it should be borne in mind that speed in operation is essential and all possible sources of delay eliminated. Great care must be exercised to provide ample floor space for mechanical handling from cars to the warehouse floor, for display of the produce and particularly for the assembly of various lots (often from several different locations on the floor) for delivery to trucks. Column spacing should be given careful study. Back up space for trucks should be as great as possible. Canopies should be provided to protect produce while unloading from cars and while delivering to trucks. There must be ample natural and artificial lighting. The roof, walls and floor should be properly insulated to control temperatures. Special attention should be given to the floor to withstand the continued trucking, and proper drainage installed to insure maintaining sanitary conditions. There are a number of other special features which must be considered, such as heating, refrigeration, air conditioning, etc., and sometimes special facilities, as for handling and ripening bananas. Space should be provided for storage of material for cooperage. Offices and auction rooms are usually located at one end of the building or in the second story. Auction rooms require exceptionally good lighting, ventilation and acoustic treatment.

Where the terminal building consists of a number of individual stores, the requirements should be worked out with the dealers. As these buildings usually consist of a basement and one or two stories, elevators will be required and often platform scales are needed.

The economical width of auction and private sales buildings appears to be between 70 ft. and 110 ft.

Driveways between buildings or between a building and a team track should be about 80 ft. wide.

Shelters, properly heated and lighted, should be provided for team yard checkers.

Track Layout

The extent of the track layout depends on the number of cars handled at peak periods and the average standing time until cars are released. In team yards where sales are made directly from the cars, these sales often consume several days. Large produce terminal yards almost invariably have and need a greater capacity than would

be required for other commodities, due to long standing time either for the reason stated above or for holding cars for diversion and to insure ample capacity for peak traffic. The layout should be designed to afford the utmost flexibility and speed of operation and should be as compact as possible, as land values are usually quite high.

The layout may include any or all of the following:

(a) Receiving Yard, especially if transfers from several railroads enter the produce terminal and if it is desired to segregate the movement of this traffic from other yard operations. This yard may also be used for assembling empties and reconsigned cars.

(b) Hold and Inspection Yard. This may be a separate yard or combined with the receiving yard and is for the purpose of holding cars and inspecting contents until the cars are ordered to the house or team tracks or until reconsigned. Narrow inspection platforms, covered and lighted, may be provided between each pair of tracks. These platforms should be 4 feet to 6 feet wide, at least 5 feet 9 inches from center line of tangent track and should be 3 feet 5 inches above top of rail.

(c) Team Yard. The size of the team yard depends on the number of cars handled at peak periods and the average standing time. Driveways should be hard surfaced and at least 45 feet wide. Modern practice tends to increase this width (in some cases to as much as 65 feet) due to peak business being handled during a relatively short period of the day and the fact that cross driveways are usually omitted in order to control trucking, facilitate checking and prevent theft. The size and shape of property available usually has some effect on the width of driveways. Inspection platforms are sometimes provided but are of questionable value in a team yard. Extremely long team tracks should be avoided.

(d) House Tracks. In order to allow of opening refrigerator car doors, tracks should be on 13 foot centers and the center line of tangent track adjacent to buildings or building platform having a floor level more than 3 feet 5 inches above top of rail should be located 8 feet from the face of building or platform. If a platform is 3 feet 5 inches or less above top of rail, center line of tangent track may be 5 feet 9 inches from the face of the platform. These clearances must, of course, conform with State requirements. Where platforms serve both cars and trucks, as is usually the case, a vertical height of from 3 feet 9 inches to 4 feet above top of rail is recommended.

Garbage and Refuse Disposal

A large amount of garbage and refuse accumulates in a produce terminal and must be disposed of promptly. In small layouts this may be done by City collection or by contract. In larger layouts an incinerator may be necessary, designed to burn garbage having a high water content. It is usually economical to install an incinerator which will handle one day's collection in eight or ten hours, to keep operating costs at a minimum and at the same time provide for emergencies and future expansion of the terminal. The temperature in the combustion chamber and the permissible density of smoke are usually fixed by law and vary in different localities. Cars should be thoroughly cleaned after unloading and all refuse and garbage removed from platforms, buildings, etc. Special equipment, such as sweepers, dump carts, etc., should be provided in large terminals.

Live Poultry Platforms

These should be 16 feet to 20 feet wide, 5 feet 9 inches from center line of tangent track and 3 feet 5 inches above top of rail. Platforms should be covered and supplied with water and light. Roof supports should be located to minimize interference

with trucking and handling crates. Usually space should bė provided near the platform for crate storage and cooperage.

General

Ample drainage is essential for both building and yards in order to maintain sanitary conditions.

Floor lighting the entire area is desirable in addition to local lighting around buildings.

The entire area should be fenced to allow close supervision and to prevent pilferage, all truck movements being made through definitely assigned entrances and exits.

A farmer's market is sometimes considered a desirable adjunct as much of the farm produce is sold to jobbers.

A cold storage warehouse is considered a desirable adjunct with suitable track service and convenient means of communicating with other buildings.

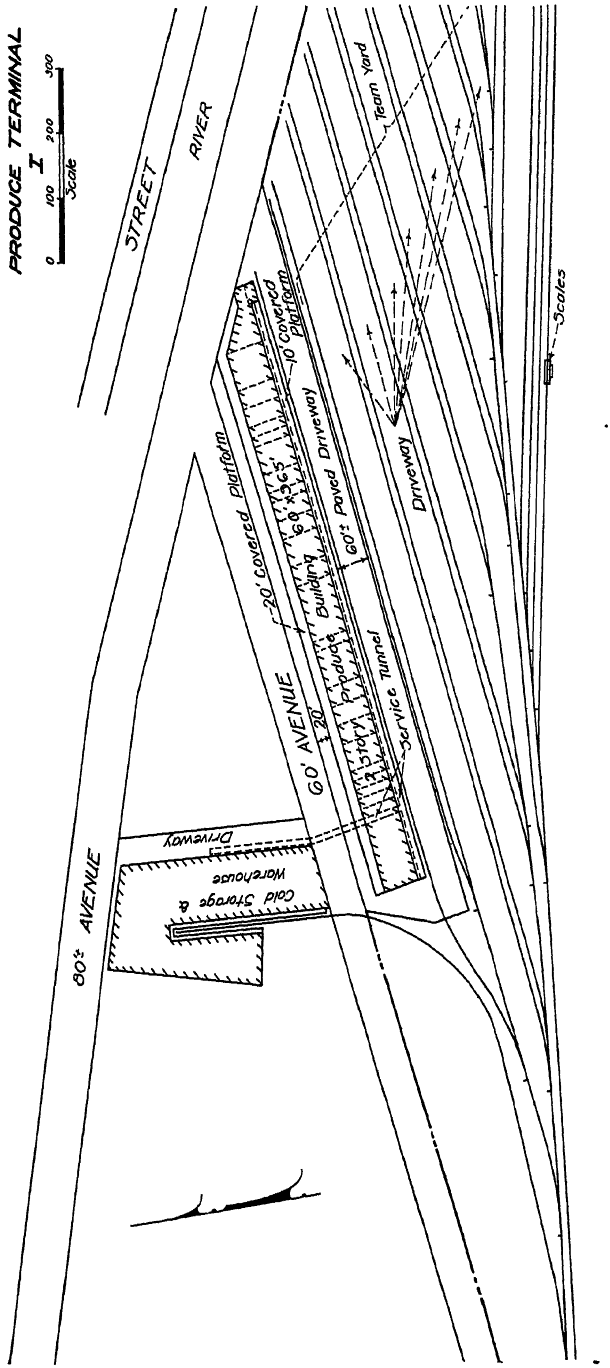
Icing is usually done by contract with local dealers. All cars in the team and hold yards should be accessible, either from driveways or icing platforms. In one large modern terminal, icing in the hold and inspection yard is done from the roof of wide inspection platforms, the ice being delivered to elevators at the ends of the platforms and handled by conveyors in the usual manner. In another terminal, icing in the hold and inspection yard is done from narrow driveways. In both cases cars in the team yard are iced from trucks with elevating bodies. The former method conserves space and might be advantageous in connection with a cold storage plant, but appears to be more expensive and less flexible than direct icing from trucks.

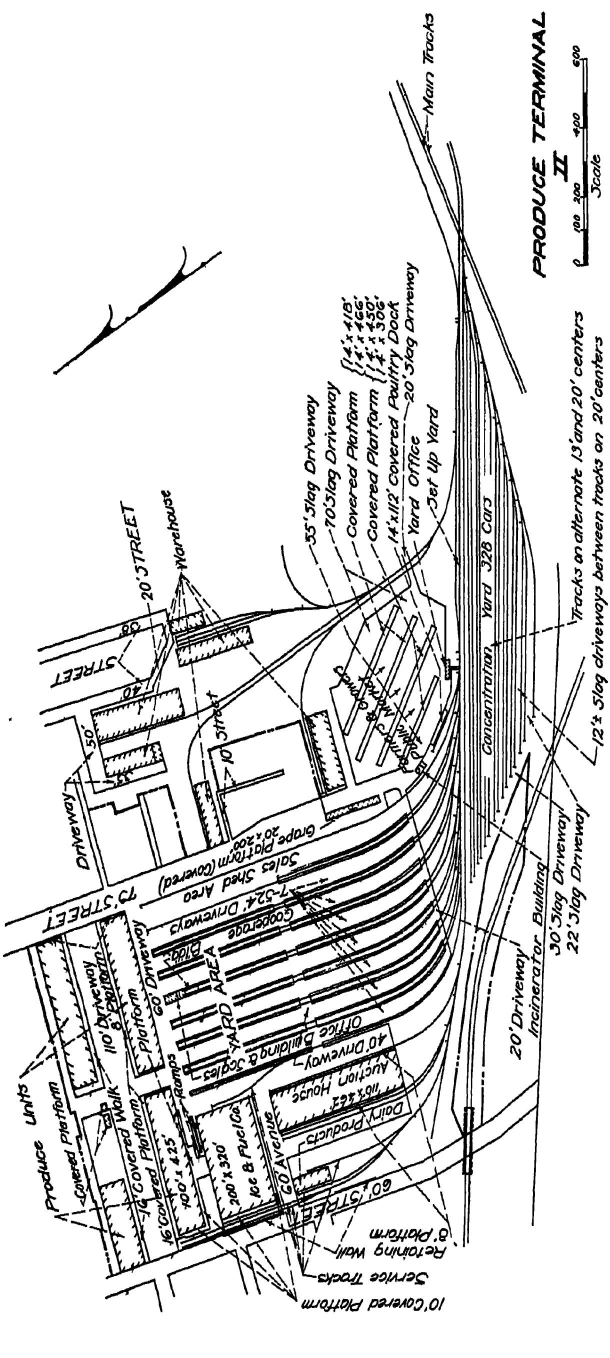
Adequate parking space for dealers' automobiles and trucks should be provided in the terminal area.

Truck scales, where required, should be located at a point convenient for the drivers, and it is desirable to have this location near the freight office.

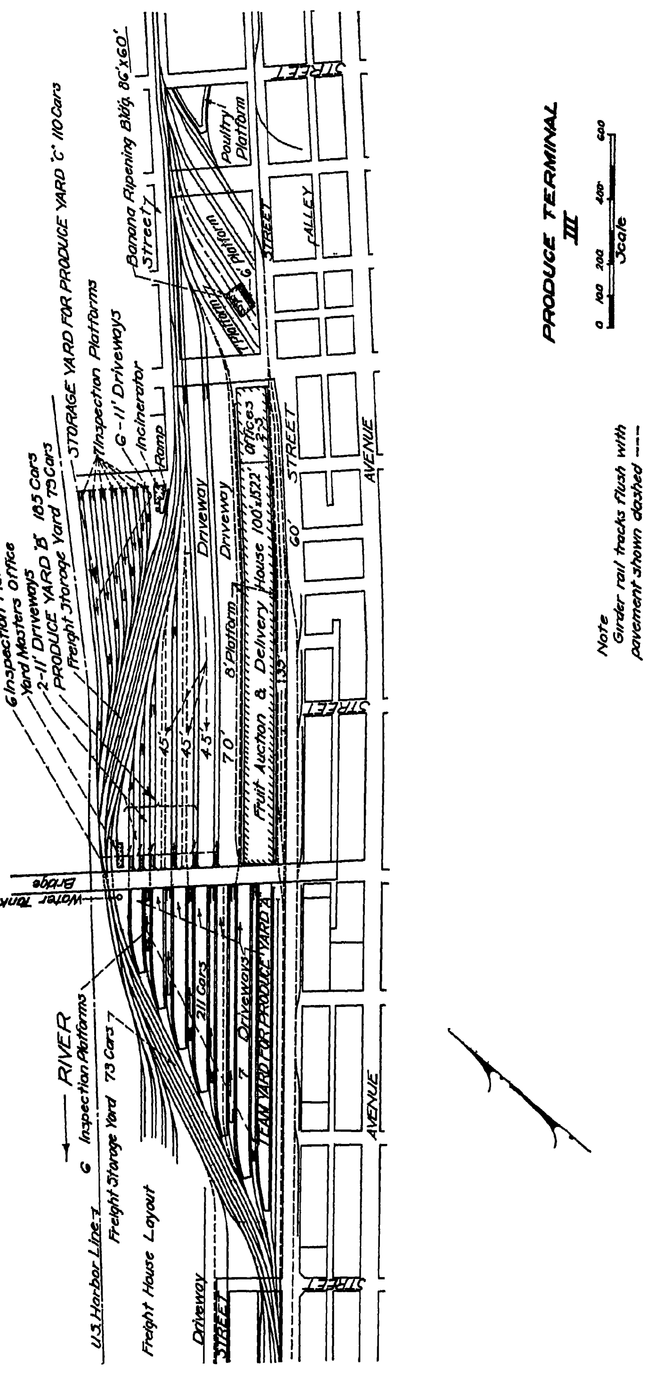
While this discussion is mainly limited to facilities for handling fruits and vegetables, there is a strong tendency to concentrate all allied food markets at one terminal, such as dressed meats and poultry, butter, eggs and cheese, groceries, canned goods, etc.

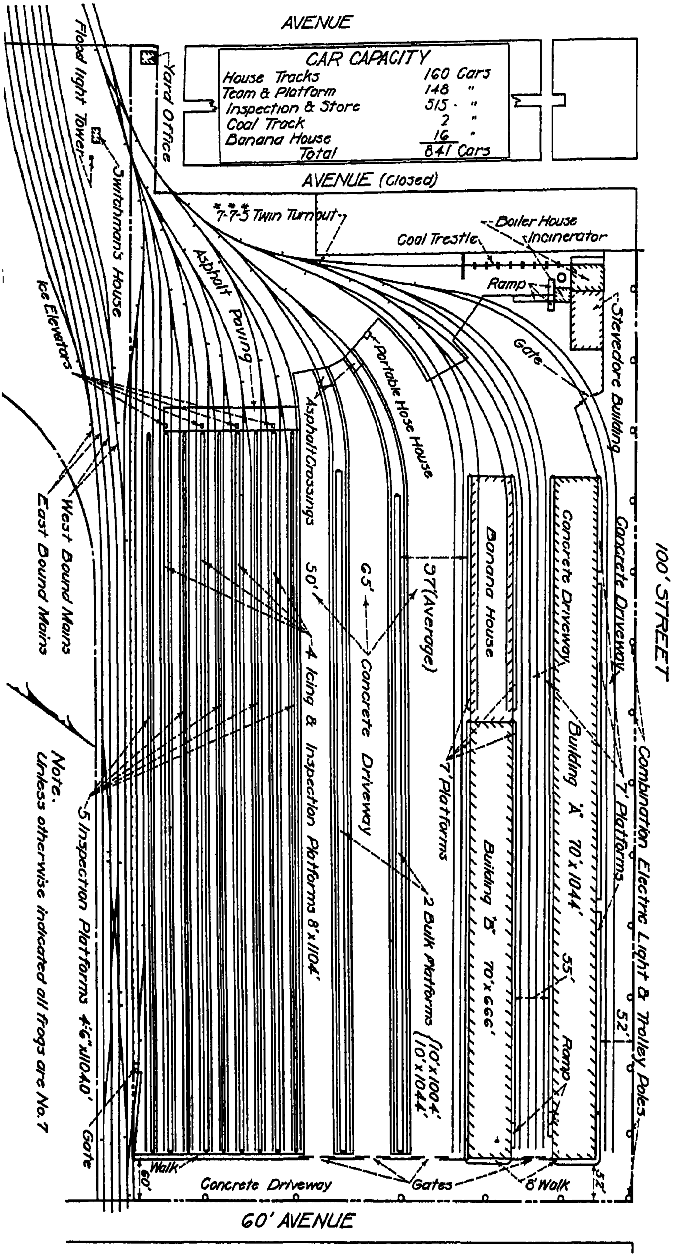
A list of some modern produce terminals and four sketch plans are offered as information.


PRODUCE TERMINAL
I
0 100 200 300
Scale
STREET
RIVER
Team Yard
10' Covered Platform
20' Covered Platform
60' x 365'
3 Story Produce Building
60'± Paved Driveway
Driveway
Service Tunnel
60' AVENUE
20'
Scales
Driveway
Cold Storage & Warehouse
80'± AVENUE



PRODUCE TERMINAL
II
0 100 200 400 600
Scale
Main Tracks
Tracks on alternate 13' and 20' centers
12'± Slag driveways between tracks on 20' centers
Concentration Yard 328 Cars
55' Slag Driveway
70' Slag Driveway
Covered Platform
Covered Platform
14'x112' Covered Poultry Dock
14'x418'
14'x466'
14'x450'
14'x306'
20' Slag Driveway
Yard Office
Set Up Yard
20' STREET
Warehouse
STREET
80
40
50'
35'
Driveway
10' Street
Grape Platform 20'x200'
Sales Shed Area (Covered)
75' STREET
7-52.4' Driveways
Cooperage
Bldg.
YARD AREA
Office Building & Scales
40' Driveway
Auction House 110'x 462'
Dairy Products
60' Avenue
Ice & Fuel Co. 200'x320'
100'x425'
Ramps
16' Covered Platform
16' Covered Platform
Covered Walk
110' Driveway
8' Platform
Platform
60' Driveway
Produce Units
Covered Platform
60' STREET
8' Platform
Retaining Wall
Service Tracks
10' Covered Platform
20' Driveway
Incinerator Building
30' Slag Driveway
22' Slag Driveway


PRODUCE TERMINAL
III
0 100 200 400 600
Scale
Note
Girder rail tracks flush with
pavement shown dashed ----
RIVER
U.S. Harbor Line
6 Inspection Platforms
Freight Storage Yard 73 Cars
Freight House Layout
Driveway
STREET
211 Cars
Driveways
TEAM YARD FOR PRODUCE YARD A
Water Tank
Bridge
6 Inspection Platforms
Yard Masters Office
2-11' Driveways
PRODUCE YARD 'B' 185 Cars
Freight Storage Yard 79 Cars
STORAGE YARD FOR PRODUCE YARD 'C' 110 Cars
7 Inspection Platforms
6-11' Driveways
Incinerator
Ramp
Banana Ripening Bldg. 86'x60'
Street
Poultry Platform
6' Platform
Driveway
Driveway
45'
45'
45'
70'
8' Platform
Fruit Auction & Delivery House 100'x1522'
Offices
60'
STREET
AVENUE
ALLEY
STREET



PRODUCE TERMINAL
IV

PARTIAL LIST OF MODERN PRODUCE TERMINALS

1	A.T.&S.F.	Los Angeles	Los Angeles Wholesale Produce Terminal
2	A.T.&S.F.–Ill. Cent.	Chicago	Chicago Produce Terminal
3	B. & O.	Baltimore	Produce Terminal
4	B. & O.	Philadelphia	B.&O. Fruit & Produce Terminal
5	B. & M.	Boston	Boston Fruit Terminal
6	Erie	New York	Piers 20 & 21, North River
7	Erie–NKP	Buffalo	Niagara Frontier Food Terminal
8	M.C.R.R.	Detroit	Michigan Central Produce Terminal
9	N.K.P.R.R.	Cleveland	Northern Ohio Food Terminal
10	N.Y.C.R.R.	Buffalo	
11	N.Y.C.R.R.	New York	Piers 16 & 17, North River
12	N.Y.N.H.&H.	Boston	Boston Market Terminal Company
13	N.Y.N.H.&H.	Providence	Providence Terminal Produce Terminal
14	P.R.R.	Ft. Wayne	
15	P.R.R.	New York	Piers 27, 28 & 29, North River
16	P.R.R.	Jersey City	Manhattan Produce Yard
17	P.R.R.	Pittsburgh	Pennsylvania Railroad Produce Terminal
18	P.R.R.	Philadelphia	Pennsylvania Produce Terminal
19	P.R.R.	Washington	
20	P.R.R.	Baltimore	Baltimore Produce Terminal, P.R.R.
21	P.R.R.–P.M.–Wabash	Detroit	Detroit Union Produce Terminal
22	Can. Nat'l. Rys.	Montreal	

Appendix C

(4) PROVISION FOR PARKING AND GARAGE FACILITIES FOR PRIVATE AUTOMOBILES OF RAILWAY PASSENGERS AT PASSENGER TERMINALS AND WAY STATIONS

E. J. Beugler, Chairman, Sub-Committee; H. L. Ripley, Irving Anderson, J. R. W. Ambrose, H. M. Bassett, C. H. Blackman, W. A. Christian, E. H. Fritch, R. J. Hammond, John V. Hanna, E. M. Hastings, E. T. Johnston, C. P. McCausland, C. H. Mottier, A. E. Owen, T. R. Ratcliff, H. M. Roeser, A. P. Wenzell.

In continuing the study of auto parking, attention has been given to the design of layouts at or near railroad stations, including joint developments made under co-operative agreement between public authorities, the railway company and other public utility interests.

Practice

Additional information received by the Committee relating to general policies in the provision for parking railway patrons' autos, indicates an increasing interest in the matter. Practice is and will continue for some time to be experimental on account of varying local conditions. There appears to be more consideration given to parking space at new or reconstructed stations in the larger cities, and at way stations in suburban towns near the larger cities. The problem at other stations is a simple one, as ground not otherwise occupied is generally at hand for parking and its dedication becomes a matter of policy.

Design

With respect to design, the layout will depend primarily on dimensions and shape of the land available, and the position of existing private thoroughfares or public highways. Fairly level ground is desirable, although connecting driveways may be on work-

able grades. Roadway and parking surfaces should provide firm bearing under adverse weather conditions. Single entrances with one or more separate exits are desirable for smooth operation and control of parking. When separate exits for one way traffic are not practicable, ample turning space should be planned.

To determine a normal space requirement for placing and moving a passenger car, experiments have been made with a medium size car having a wheel base of 124 in. and over-all measurements of 6 ft. in width at running board and mud guards, and 16 ft. in length between bumpers. With larger cars, somewhat more care will be required in maneuvering to and from the allotted space.

Unit space should generally measure 8 ft. in width and 18 ft. in length, except for longitudinal or parallel parking along curb where a width of 7 ft. and a length of 21 ft. may be adopted. In no case should side by side spacing be less than 7.5 ft. in width for public use. The angle of parking relative to line of approach roadway may vary from 30° to 90°. Where width is available for the wider driveway, 90° parking gives the most economical use of a definite area, although 45° angle parking, which is preferred by some drivers, can be arranged to advantage on larger layouts. Fig. 1 shows normal requirements for auto parking space and driveways with various angles. The arrows indicate direction of movement on entering and leaving a given space. One way traffic is shown for all angles except the 90° scheme where movements can be made either way with equal facility. Exit operation on 90° will be rendered more speedy by parking the car headed out. On other angles parking head in will result generally in safer and smoother movements. Longitudinal parking in limited space necessitates backing in. On 45° parking, space may be conserved by the use of a central zig-zag curb or barrier between two lines of cars arranged as indicated by dashed lines on Fig. 1.

Three developments employing various arrangement of parking units and driveways are shown on Fig. 2. 2A is located in a southern city and represents the combined use of railway and city property, above track level. 2B shows the rearranged station approach to an eastern station in which are provided convenient and separate means of access from patrons' autos, cabs, street railway, and for foot passengers. This was accomplished by constructing a cross-walk between the station entrance and a new platform serving the shifted trolley line, with protected parking space and minimum interference with vehicular traffic on the adjoining street.

2C illustrates the use of an irregular space adjacent to a large station, common to many cities. The situation is similar to an actual development in a western city. The layout of units is intended to show various combinations of use in covering the available space.

Garage Facilities

The provision of garage or repair facilities by railroad companies in connection with station parking does not appear to be common. It would seem that this phase of service would more properly be taken care of by a concessionnaire or an independent concern.

Recommendations

In view of the present experimental nature of this matter, the Committee recommends that the design data and typical cooperative layouts be received as information and that the subject be discontinued for the ensuing year.

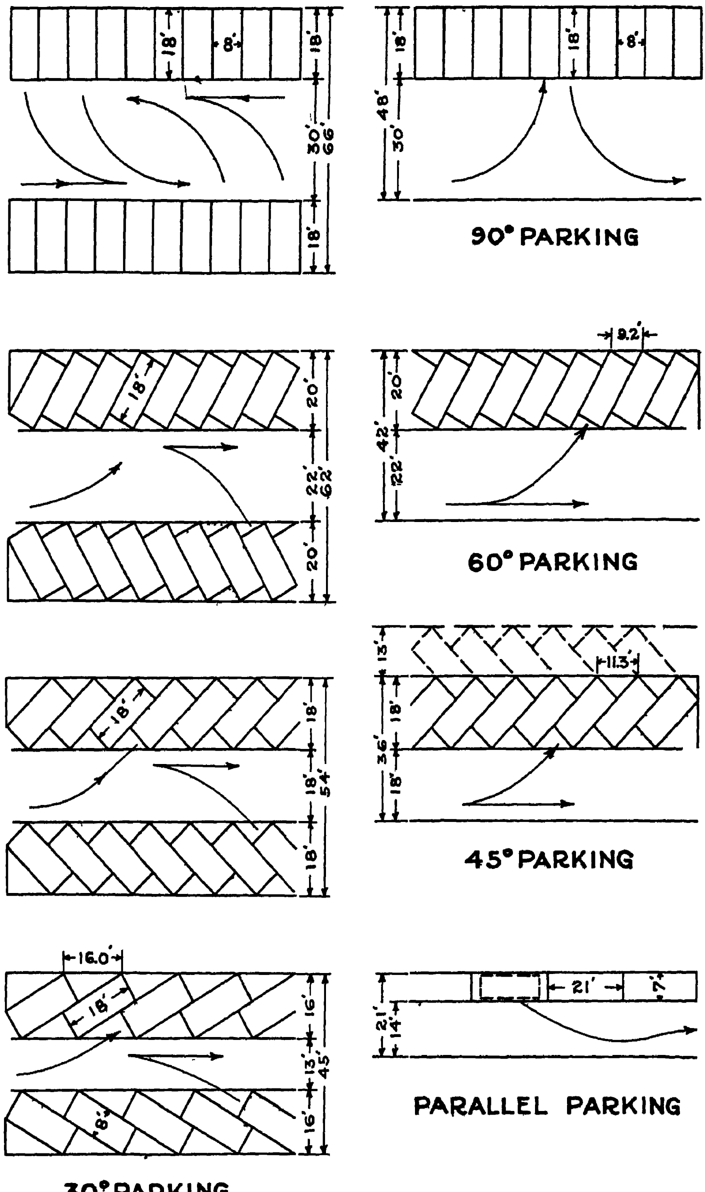
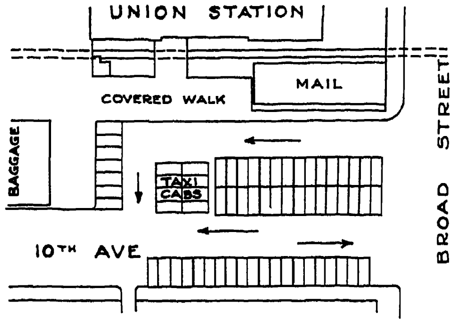


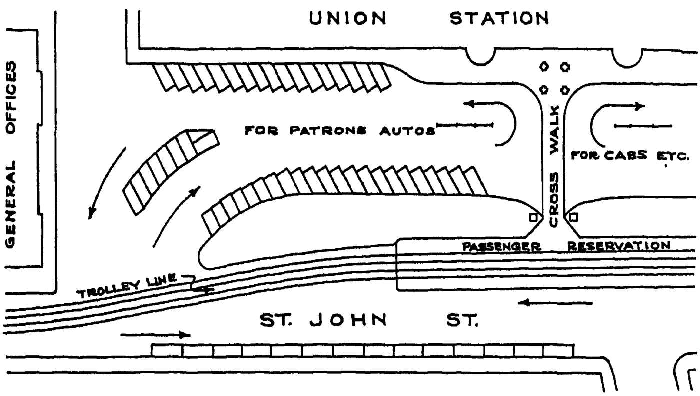
FIG. 1

AUTO PARKING SPACE UNITS

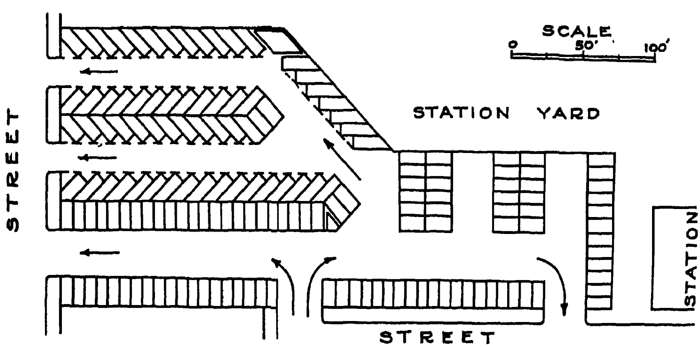
DIMENSIONS SHOWN PERMIT EASY MOVEMENTS. WHERE GROUND AREA IS LIMITED LESS CLEARANCE BETWEEN AUTOS MAY BE ADOPTED. WIDTH SHOULD NOT BE LESS THAN 7.5' FOR PUBLIC PARKING.



PARKING ON VIADUCT CONSTRUCTION -A-
TRACKS UNDERNEATH



REARRANGED SPACE FOR PARKING BY JOINT AGREEMENT BETWEEN R.R.CO. CITY & ST. RY CO. -B-



USE OF IRREGULAR SPACE ADJACENT TO STATION -C-

VARIOUS PARKING ARRANGEMENTS FOR AUTOS AT RAILWAY STATIONS FIG.2

Appendix D

(6) HUMP YARDS

R. J. Hammond, Chairman, Sub-Committee; H. L. Ripley, M. J. J. Harrison, J. R. W. Ambrose, C. E. Armstrong, J. E. Armstrong, Wm. Atwill, N. C. L. Brown, H. F. Burch, W. F. Cummings, W. H. Giles, G. F. Hand, E. M. Hastings, C. T. Jackson, E. K. Lawrence, L. L. Lyford, A. E. Owen, T. R. Ratcliff, H. M. Roeser, W. B. Rudd, W. C. Sadler, A. P. Wenzell and J. L. Wilkes.

The Committee has collected and studied additional information in regard to gradients during the past year and has reviewed the reports which it made to the Association at its annual meetings in Chicago in March, 1930, published in Vol. 31, page 781, and in March, 1931, Vol. 32, page 210. It wishes to reiterate the matter contained therein and, in order to save space and printing, to include it by reference in this year's report.

Repeating, for emphasis, the caution that there are many factors affecting efficient operation of a retarder yard local to each situation and each terminal must be studied independently to produce a proper design, your Committee offers the following tentative formulae and method of procedure as a guide to laying out the hump and yard gradients for a typical installation. It solicits constructive criticism and suggestions from the membership, together with maps and profiles of existing yards, and, in particular, information relative to changes that have been found from experience to be necessary or desirable, together with full narrative description of the causes found for the unsatisfactory operation, the remedies applied, and the result of that remedial application, as more can be learned from partial failures and their correction than from any other source.

Experience has demonstrated the great advantage in the group track arrangement over the former ladder type track arrangement for retarder layouts, as regards both first cost and operating cost. The advantage of reduced length obtained by the use of lap switches, resulting in less hump height, more than compensates for any disadvantage there may be in a lap switch.

The following formulae may be used in designing retarder hump yard gradients from the crest of the hump to the lower end of the classification yard. The results are in terms of the required vertical drop.

$A =$ Total drop in feet from the crest of the hump to the clearance point of any track in the classification yard (Distance $D + D_1$) = not less than $DZ + D_1Z_1 + \Delta C$.

$B =$ Drop in feet from leaving end of last retarder in any group to clearance point of any track in the group (Distance D_1) $= D_1Y + \Delta_1C_1 + a + b$.

$A\text{–}B =$ Drop in feet from crest of hump to leaving end of last retarder.

$C =$ Curve resistance of hard rolling cars under adverse conditions expressed in feet drop per degree of central angle.

$C_1 =$ Curve resistance of easy rolling cars under favorable conditions expressed in feet drop per degree of central angle.

$D =$ Distance along the track from crest of hump to leaving end of last retarder.

$D_1 =$ Distance along the track from leaving end of last retarder to clearance point of any track in the group.

$\Delta =$ Total curvature in degrees of central angle in distance $D + D_1$.

$\Delta_1 =$ Total curvature in degrees of central angle in distance D_1.

$Z =$ Per cent gradient equivalent to the average resistance of hard rolling cars under adverse conditions in distance D.

$Z_1 =$ Per cent gradient equivalent to the average resistance of hard rolling cars under adverse conditions in distance D_1.

Y = Per cent gradient equivalent to the average resistance beyond the last retarder, under favorable conditions (summer weather, assisting wind, etc.) of the heavy easy rolling cars normally handled.
a = Switch resistance in distance D_1.
b = Allowance in feet drop for accelerative increment over and above all other resistances in distance D_1.

The quantities to be substituted for the different symbols may be determined from tests at yards now in operation. If the layout requires four points of retardation in each route or if the distance from the crest of the hump to the last retarder is unusually long, it may be necessary to divide the distance D into two parts each with its own rate of maximum resistance, modifying Formula A accordingly.

The distance D_1 is usually considered as extending from the leaving end of the last retarder in any group to the straight portion of the classification tracks, or as much farther as is necessary to reach the most distant clearance point in that group. This point in the yard is that which it is intended all cars shall reach before stalling under adverse conditions. If it is desired to deliver the hard rolling cars (empties) under adverse conditions to a point farther down in the classification yard, it will be necessary to add to formula A, D_2Z_2 representing respectively the additional distance from the clearance point to such farther point and the gradient equivalent to the average resistance of hard rolling cars under adverse conditions over distance D_2 (Z_2 could be expected to be smaller in amount than Z_1).

Having determined the required vertical drops from the crest of the hump to the leaving end of the last retarders and from these points to the selected clearance points in the yard by the above formulae, the drops should be distributed in their respective zones to best meet the operating requirements. However, by taking advantage of the full retarder capacity, it may be possible to increase these drops if that will reduce the amount of grading or be of other advantage.

Starting at the crest of the hump, the first gradient should be steep enough and long enough to separate the cuts quickly to provide the spacing necessary for the free throwing of switches, and to prevent cuts coupling in the first retarder. Depending on the class of traffic, the gradients through the last retarders preferably should be from 0.8 per cent to 1.2 per cent to assist in starting and running into clear, cars which may be stopped in the last retarder. The necessary curve compensation having been included in Formula B, there is no necessity for its being applied entirely to the curve itself and part of it may be put in advance of the curve.

It will be noted that Formula A provides a total drop which may be different for each track, with the sides of the yard lower than the center because of the greater curvature in the outside tracks. The following are practical methods of application:

1. Grade the classification tracks so that each track has its proper amount of curve compensation. This is done by determining the drop to the leaving end of the last retarder (A–B) for the maximum curvature track of each group. The additional drop to clearance point of each track in the group is then determined by Formula B.

This makes the cross-section a series of steps which is not objectionable providing the difference in elevation does not exceed 8 inches for adjacent tracks spaced with 13 feet centers.

This method provides the most uniform rolling conditions beyond the last retarder.

2. The method described in (1) may be modified by lowering the higher groups of tracks to elevations nearer those of adjacent tracks, if this is of advantage (See Fig. 1).

3. Grade in the same plane all tracks in the same group. In this case both Formulae A and B are used for the track of greatest curvature for each group.

The cross-section will be a series of steps by groups and it may be necessary to adjust elevations as described in (2) to provide permissible difference in elevation between adjacent tracks in different groups.

The grading of all tracks in a group in the same plane as the track having greatest curvature will result in the acceleration of heavy easy rolling cars on the tracks of lesser curvature. For such cars, decreased releasing speed from the last retarder is necessary to avoid excessive speed on the tracks with lesser curvature.

4. The method described in (3) may be modified by using Formula B for the track of least curvature instead of for the track of greatest curvature in each group. The total drop, A, remains unchanged.

The grading of all tracks in a group in the same plane as the track having the least curvature will result in deceleration on the tracks of greater curvature. With this method a higher releasing speed will be required for some tracks.

5. Grade all classification tracks in the same plane. In this case Formula A is used for the track of greatest curvature for the yard. Formula B is used as in (3).

With this method cars will accelerate on tracks of lesser curvature as explained in (3).

6. The method described in (5) may be modified by using Formula B for the track of least curvature as in (4).

With this method cars will decelerate on tracks of greater curvature as explained in (4).

7. A further modification of the above would be in omitting or giving a negative value to b the accelerative increment found in Formula B without changing the total drop A. This would result in increasing the releasing speed of all cars.

The quantities representing the different symbols in the formulae will vary due to:

1. Weight and proportion of heaviest cars.
2. Kind of lading.
3. Lengths of D and D_1.
4. Whether or not hot oil is used in the journals.
5. Whether or not flange oilers are used.
6. Extremes of temperature encountered.
7. Prevailing direction and velocity of wind.
8. Quality of track in respect to surface, line and firmness of sub-grade.

In yards handling both heavy loads and empties, gradients below the last retarder must be provided on the basis of the heavy, free rolling car unless such cars are so few that the operation of the yard will not be slowed up appreciably by the necessity for bringing these cars practically to a stop in the last retarder. The Committee believes that the heavy free rolling car under favorable conditions should not accelerate unduly after leaving the last retarder. The amount of permissible acceleration, therefore, will depend on the speed at which such cars are released from the last retarder. Obviously, retarding cars almost to a stop in the last retarder necessitates stopping the hump operation at intervals. On the other hand, higher speeds leaving the last retarder will permit higher humping speed and increased humping capacity of the yard. It is conceivable that b in Formula B may be made a minus quantity as in method (7), thus introducing a decelerating gradient between the last retarder and the clearance point, without, however, decreasing the total drop determined from Formula A; this would necessitate a higher releasing speed at the last retarder.

As an illustration of the quantities to be substituted for the different symbols, the following results of tests made at the Cedar Hill Yard of the New York, New Haven and Hartford Railroad are given:

$Z = 1.4$ per cent gradient.
$Z_1 = 0.9$ per cent gradient.
$Y = 0.22$ per cent gradient.
$C = 0.045$ feet per degree of central angle.
$C_1 = 0.025$ feet per degree of central angle.
$a =$ Single switch 0.06 feet, lap switch 0.12 feet.

Tests made at the Pitcairn Yard of the Pennsylvania Railroad confirm the values obtained at Cedar Hill for Y and C_1, and indicate the correctness of C. They also indicate that a obtained at Cedar Hill may not be due so much to switch resistance as to a higher average speed of cars through the switch zone.

The following example is worked out for a typical yard as shown in Fig. 1 with 45 classification tracks on 13-ft. centers, divided in groups of five with three retarding positions, two retarders in each position, making six retarders in each route. Grading method (2) is used. This typical layout incorporates the preceding recommendations with regard to group arrangement, with lap switches to reduce to a minimum the distance from the crest of the hump to the clearance points in the yard. The 35 ft. space between a retarder and the following switch point is to provide for the track circuits protecting the switches. The total drop for the two outside tracks, Nos. 43 and 44, would be calculated as follows:

$D = 785$ feet.
$D_1 = 409$ feet.
$Z = 1.4$ per cent.
$Z_1 = 0.9$ per cent.
$Y = 0.22$ per cent (for coal cars of gross weight 70 tons or over).
$\Delta = 61.1°$.
$\Delta_1 = 37.7°$.
$C = 0.045$ feet per degree.
$C_1 = 0.025$ feet per degree.
$a + b = 0.25$ feet.

I. Total drop from the crest of the hump to clearance point $= A = (785 \times 1.4$ per cent$) + (409 \times 0.90$ per cent$) + (61.1° \times 0.045) = 17.42$ feet.

II. Drop from leaving end of last retarder to clearance point $= B = (409 \times 0.22$ per cent$) + (37.7° \times 0.025) + 0.25 = 2.09$ feet.

III. Drop from crest of hump to leaving end of last retarder $= A-B = (17.42$ ft. $-$ 2.09 ft.$) = 15.33$ feet.

For the purpose of this illustration retarders have been used with a retarding capacity of 2.2 ft. velocity head each when applied to a 100 ton car. The total permissible drop (from crest to clearance point) will then be figured as follows:

6 retarders at 2.2 ft.		= 13.20 feet
785 ft. of track at 0.3 per cent (rolling resistance, including switches)		= 2.36 feet
23.4° curvature above last retarder at 0.025 ft. per degree compensation		= 0.59 feet
Total Retardation		= 16.15 feet
Velocity head at hump for 3 miles per hour	.3	
Margin of safety	.5	= 0.80 feet
Permissible drop from crest to leaving end of last retarder leading to outside tracks		= 15.35 feet
Calculated drop from last retarder to clearance point		= 2.09 feet
Total Drop		= 17.44 feet

It will be noted the required total drop, Formula A, is 17.42-ft., but this is increased to 17.44-ft. to utilize the full capacity of the retarders. The curvature of the remaining four tracks in each of these two outside groups is 14.3° less than the curvature of tracks No. 43 and No. 44, which results in the plane of these four tracks being higher, due to the lesser amount of compensation at the rate of 0.025-ft. per degree,

as shown in Fig. 1. The required and the practical drops for the remaining groups are determined similarly; for example, tracks No. 13 and No. 14 from the formula would have a required total drop of 15.26-ft. and to use up the full capacity of the retarders this may be increased to 16.51-ft. (including 1.78-ft. drop from last retarder to clearance), as shown in Fig. 1, or the retarders in the second and third positions may be decreased in length (decreased in retarding capacity). If the cross-section of the yard were made flat, with the plane of the yard determined by the required drops for track No. 43 and No. 44, additional retarders would be required in the center groups.

Having determined the drops from the hump to the last retarder and to the clearance line, the equivalent gradients may be worked out. For the yard in question it would be good practice to allow a drop from the crest of the hump to the leaving end of the second retarder based on a fully retarded 100-ton car under favorable conditions leaving the second retarder at a speed of six miles per hour. In the layout in Fig. 1 this would be 5.90-ft. drop. There is sufficient retarder capacity to stop a car in the last retarder with a margin of safety of 0.5-ft. drop.

The gradient of the body tracks would be 0.22 per cent and if there are curves in the body tracks they should be compensated at the rate of 0.025-ft. per degree of central angle, unless such curves are so located that there would be no objection to the cars decelerating. It is advisable to have an up-grade in the body tracks just in advance of where they join the ladders at the lower end of the yard, with a rise equal to the velocity head of cars reaching that point, say, equivalent to a speed of four miles per hour.

Appendix E

(7) COORDINATION OF FACILITIES AT RAIL AND WATER TERMINALS

C. U. Smith, Chairman, Sub-Committee; H. L. Ripley, M. J. J. Harrison, C. E. Armstrong, C. J. Astrue, Wm. Atwill, H. M. Bassett, C. H. Blackman, N. C. L. Brown, H. F. Burch, W. F. Cummings, E. H. Fritch, R. J. Hammond, C. T. Jackson, C. P. McCausland, C. H. Mottier, W. B. Rudd, W. C. Sadler, E. E. R. Tratman.

Since 1929, the Committee has been engaged in compiling information by means of a questionnaire for the purpose of obtaining data from railroads and public ports with reference to water terminal facilities. A preliminary compilation of the data obtained became available on October 1st, 1931.

Since the assignment of this subject to Sub-Committee No. 7, Committee XXV—Rivers and Harbors, has been organized as a Standing Committee instead of a Special Committee and a good deal of the data that it was the original intent to develop, has been assigned to that Committee.

Of 113 questionnaires which have been circulated, 87 usable returns have been received, a total of 78 per cent. Of these, 64 reports cover ocean ports, 19 lake ports and 4 river ports; further classified as 53 private and 34 public ports.

The questionnaire consists of 15 sections, all of which have been analyzed, but not in time to be handled in this year's report. These sections of the questionnaire are as follows:

1. General
2. Ownership and operation
3. Slip capacity and maintenance
4. Open storage
5. Merchandise piers
6. Coal piers
7. Ore docks
8. Oil and gasoline docks
9. Car ferry or car float slips
10. Docks or piers not above specified
11. Warehouses
12. Grain elevators
13. Industrial developments
14. Rail terminal facilities
15. Roadways and highways

After consultation with Committee XXV, it is the recommendation of the Committee that sections 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12, be referred to Committee on Rivers and Harbors, and the information obtained by questionnaire covering these sections be reported upon by that Committee. It is the recommendation that the balance of the questionnaire, sections 2, 13, 14, and 15 be retained as subjects for this Committee to be further reported upon at a subsequent date. Information obtained with reference to the first section, General, to be made available to both committees, as it requires no specific report.

The matter of definitions has, after conference, been left entirely with Committee XXV which has incorporated in its report on Definitions, those which pertain to the work of this Committee, as well as those pertaining to its own work.

The complete report of the preliminary analysis of the questionnaire will be filed with the Secretary of the Association so that it may be available for advance information on the part of anyone especially interested in the subject.

Appendix F

(9) SCALES

M. J. J. Harrison, Chairman, Sub-Committee; J. E. Armstrong, C. H. Blackman, A. Bousfield, W. A. Christian, A. W. Epright, E. D. Gordon, G. F. Hand, E. M. Hastings, H. O. Hem, E. K. Lawrence, Jos. L. Loida, C. P. McCausland, T. R. Ratcliff, H. L. Ripley, H. M. Roeser, H. L. Vandament, W. M. Wilson.

TRACK SCALE TEST WEIGHT CARS

In the report of this Committee to the 1931 convention (page 214, Vol. 32, Proceedings, A.R.E.A.), mention was made of the preparation of a detailed code of Specifications for Test Weight Cars, based on material now included in the Manual. Since the preparation of that report, a contact group was formed, consisting of representatives of your Committee, the Committee on Car Construction of the Mechanical Division, A.R.A., and the originators of the specifications, the National Scale Men's Association.

Several changes in the original form were suggested and agreed to by the contact group, and the revised specifications were subsequently approved by the two committees and the originating association. In their revised form, the Specifications for Railway Track Scale Test Weight Cars are herewith presented as information.

SPECIFICATIONS FOR RAILWAY TRACK SCALE TEST WEIGHT CARS

Foreword

The specifications herein set forth were prepared originally by a committee formed within the membership of the National Scale Men's Association under authority of a resolution adopted in convention at Milwaukee, Wis., on April 10th, 1929. The intent was to distinguish as clearly as might be possible between satisfactory and other types of testing equipment.

The specifications thus prepared were adopted by the National Scale Men's Association in convention at Chicago, Ill., on March 10th, 1930. Subsequently the Committee on Yards and Terminals of the American Railway Engineering Association took cognizance of the specifications and brought them to the attention of the Committee on Car Construction, Mechanical Division, American Railway Association. It appeared that the latter committee would take exception to certain features in the original specifications, and a conference committee representing each of the organizations concerned was therefore formed to undertake desirable revision.

As presented herein the revised specifications had the approval of the Car Construction Committee and were acceptable to the aforementioned conference committee. They were submitted to the National Scale Men's Association in convention at Pittsburgh, Pa., on April 15th, 1931, and were formally adopted.

(I) Definition

1. A railway track scale test weight car is a car used for determining the weighing performance of railway track scales, and as an accessory in determining their mechanical condition. Such cars are essentially standard test weights and must be given the consideration becoming to formal standards of mass.

(II) Classification

1. According to the body design, test weight cars are classified into two types. The first named is the preferred type.

(a) Self-Contained Type.—The "self-contained" type of test weight car has a body made up of either one or two castings, with space provided to contain a small number of fifty-pound standard test weights.

(b) Compartment Type.—The "compartment" type of test weight car has a body either of castings, or built up of steel shapes and heavy plates with space for standard test weights of fifty or one hundred pounds each to a value at least equal to the weight of the empty car.

(III) Primary Requirements

1. Weight.—The nominal weight of any test weight car shall be some integral multiple of 10,000 pounds.

(a) Minimum Weight.—A car used for track scale testing purposes must not weigh less than 30,000 pounds.

(b) Maximum Weight.—The weight of a track scale test weight car should be as great as conditions of roadbed, bridge restrictions, and other essentials of safe transportation and use permit. (Cars weighing 80,000 pounds comprise a majority in use. The tendency is toward heavier cars. Some are in use that weigh 100,000 pounds. Certain useful and recommended testing practices require a light car and a heavy car in combination. For these purposes it is preferable that the weight of the heavy car be a simple multiple of the weight of the light car.)

2. Design Characteristics.—The following features of design are required of satisfactory track scale test weight cars:

(a) All-metal construction.

(b) Two-axle construction, with wheelbase not to exceed seven feet.

(c) Load uniformly distributed on wheels.

(d) No air-operated brakes (see Section VI, paragraph 5, herein).

(e) Roller, or other form of anti-friction journal bearings.

(f) No unnecessary equipment.

(g) A minimum of ledges, cavities or projections that will hold dirt, water, or other foreign matter.

(h) Minimum surface area.

(i) Smooth and sloped top to insure drainage.

(j) Accessibility of all parts for inspection.

(k) Ruggedness and durability in order to minimize repairs.

(IV) Body Features

1. Castings.—Body castings shall be of gray cast iron or semi-steel and must be smooth, uniform, and free from blowholes, blisters and shrinkage cracks. Fins and burrs must be removed. Castings must be cleaned by sand blasting or other equally effective methods. Adequate allowance must be made for finish on parts that require machining.

2. Distribution of Body Weight.—The design and construction shall be such that the body weight is symmetrically distributed about either side of vertical planes through the longitudinal and transverse center lines. The center of gravity shall be as low as practicable and in any event low enough to insure safe transportation at usual operating speeds.

3. Body Shape.—The sides and ends of test car bodies shall be vertical. The top shall be symmetrical about the longitudinal center line and, exclusive of runways, shall have a slope of approximately 1 to 5.5. Necessary pockets and recesses shall in so far as possible be made self-cleaning. The design must provide reasonably easy accessibility of every part of the body for hand cleaning by brush or air nozzle.

4. Size.—The size of the body shall be such that the overall dimensions of the car will come within the clearance diagram of the owner road within the margins required by formal regulations for safety and not exceed existing A.R.A. Clearances.

5. Tool, Supercargo and Weight Compartments.—Each test car shall be provided with a tool and supercargo compartment which shall run transversely through the body of the car.

(a) Method of Closing.—All compartments shall be closed with doors dust and water tight. Doors shall be freely hinged and shall not be too heavy for one man to lift or swing.

(b) Locks.—Compartment doors shall be provided with means for locking with padlock, combination lock or other equally effective device.

(c) Drainage.—Means for drainage of accumulated moisture quickly and completely from all compartments shall be provided.

(V) Running Gear

1. Wheels and Axles.—Wheels and axles shall be of forged steel and shall conform to A.R.A. rules for strength, quality and workmanship. Wheels shall be 36 inches in diameter.

2. Journal Bearings.—Test cars shall be equipped with roller or ball bearings of an approved type designed for oil lubrication. Boxes shall be constructed to prevent

loss of oil at all running speeds. The design shall permit easy examination of bearings and renewal of lubricant. Means for draining oil from each box shall be provided. Bearings must be constructed to take lateral thrust. In all respects the type of bearing must meet A.R.A. standards for performance and safety.

3. Pedestals.—The bearing boxes shall fit between pedestal jaw castings rigidly attached to the car body. Renewable steel wearing plates shall be provided.

4. Springs.—Semi-elliptical springs of adequate design, and suitable means to protect same against corrosion, shall be provided.

5. Stability of Movement.—The design of the running gear in combination with the body must provide against the possibility of derailment due to spring failure, or due to galloping, side or diagonal sway on any track passable for running or switching purposes at the usual speeds of freight movement. Spring stops are recommended. Bottoms of journal boxes in nominal position shall have not less than 1½ in. clearance over pedestal tie bars or caps.

(VI) Brake Gear

1. Hand Brakes.—Test cars shall be equipped with an efficient hand brake conforming to A.R.A. standards.

2. Air Line.—Test cars shall be equipped with an 1¼ in. through, self-draining air line, standard angle cocks and hose connections.

3. Brake Beams.—Brake beams shall be A.R.A. standard.

4. Brake Shoes.—Brake shoes shall conform to A.R.A. standard and shall be painted red, or some other distinctive color which shall be specified by the owner road.

5. Air Brakes.—Air brakes are considered detrimental to the maintenance of accuracy of weight. When operating rules of the owner road require, they may be installed.

(VII) Draft Gear

1. Draft gear shall be of the friction type, conforming to A.R.A. standards and specifications.

(VIII) Couplers

1. Type.—Couplers shall be A.R.A. standard—bottom operated.

2. Striking Plates.—Removable striking plates shall be securely fastened to the car body back of the coupler horn, designed to take coupling shocks in the event of failure of the draft gear.

3. Painting.—Couplers, lifting mechanism and knuckles shall be painted red or some other distinctive color which shall be specified by the owner road.

(IX) Safety Devices

1. Safety appliances must conform to I.C.C. requirements.

(X) Fittings

1. Standard.—Fittings such as flag brackets, lamp sockets, etc., shall be installed as required by formal regulations.

2. Repair Warning.—A metal plate shall be securely fastened to each side of the car, or where it is conspicuously visible from both sides of the car, bearing the following legend in one-inch letters, "Do not oil boxes or make repairs to this car unless directed by scale inspector."

3. Carding Plate.—A small plate or fixture shall be attached to each side of the car to permit the fastening or holding of routing tags or cards.

(XI) Painting

1. Filler.—After sand blasting, the surface shall be further prepared for painting by application of a suitable metal primer and filler such as commonly used for machine tools, locomotives and tanks.

2. Finish.—Paint and finish, except as otherwise specified herein, shall be as specified by the owner.

(XII) Stenciling

1. Weight Legend.—The designed weight shall be conspicuously stenciled on each side of the car.

2. Warning Legend.—The following warning shall be stenciled on each side of the car in letters at least 3 inches high, "Haul on Rear End of Train."

3. Standard.—Other stenciling shall be as required by the owner.

(XIII) Supercargo Identification

1. Marking.—Car movers, tool boxes, clothing containers and all items of supercargo furnished with the car are not part of the car weight and shall be conspicuously marked by painting, badge or otherwise to furnish easy and positive identification as parts not included in the nominal weight of the car.

(XIV) Compartment Cars

1. Types Prohibited:

(a) Split Body.—Compartment cars consisting essentially of two compartments extending longitudinally divided by a runway on the car center line at the floor level are unsatisfactory.

(b) Scrap Metal, Billet or Other Lading.—Compartment cars loaded with billets, scrap metal, concrete, or any material except standard test weights of known value are unsatisfactory.

2. Lading to be Fixed.—Means shall be provided to prevent shifting of the lading of compartment cars. This may be accomplished by means of pockets, grooves, wedging, or otherwise. The possibility of damage to lading or car due to shocks of handling must be positively and permanently eliminated.

Appendix G

THE BEARING VALUE OF PIVOTS FOR SCALES

Foreword

A canon of weighing machine design requires that pivots shall be long enough to sustain applied loads without crushing or breaking down of the "knife-edges", the trade term for the load-supporting elements of scale pivots. Practical circumstances, however, demand the violation of a most fundamental canon of structural design, namely, that allowable stress shall not exceed the elastic limit of the material. To explain briefly; in order to obtain accuracy of load transmission, the knife-edges of any lever must be parallel lines. This requirement means that, in manufacturing practice, the knife-edges must be ground sharp. The theoretical consequence is that surfaces of zero area are expected to support finite loads, or, in other words, the unit stress is infinite. Inevitably, then, the deformation of the edges of scale pivots is not elastic, but plastic, a conclusion supported by observation and experience.

Since the theoretical analysis of the performance of a knife-edge under load has all the characteristics of a classical problem, the fact that mathematical literature contains nothing whatever upon it testifies to its baffling nature. A search of technical literature discloses no previous record of experimental research to establish safe loading values. Practically, therefore, the designer has had to depend upon empirical conjecture which, together with a combination of fortuitous circumstances, has met the demands of the trade with some satisfaction. Brauer, the German authority, whose treatise "The Construction of the Balance", is recognized as the outstanding textbook on design, mentions that loads ranging from 5600 to 22,400 lb. per lin. in. of knife-edge are or were considered as acceptable maxima in Germany. Present American practice regards 5000 to 7000 lb. per lin. in. as maxima, depending upon the material used for pivots and the conditions of service for which particular scales are designed.

Acknowledgments

The Engineering Experiment Station of the University of Illinois, of which Dean Milo S. Ketchum is the Director, has just completed an investigation of the Bearing Value of Scale Pivots. This work was done by Ray L. Moore and Frank P. Thomas, working under the direction of Prof. Wilbur M. Wilson.

A complete report of this investigation has been prepared by Prof. Wilson and will be published in due time as a Bulletin of the Engineering Experiment Station. Your Committee has had the privilege of reviewing this report in manuscript form, and has prepared an abstract thereof, a copy of which has been deposited with the Secretary of the Association. The material presented here consists essentially of the conclusions indicated by the results of the investigation.

Object and Scope of Investigation

The principal object of the investigation was to determine the maximum supporting strength of pivots and bearings. (Note.—The "bearing" is the member which bears against the pivot edge. It is usually of hardened steel, with surface either flat, concave, or "V" shaped. In the investigation here referred to, the bearing surfaces were flat.) Studies were made to determine the effect of—

(1) magnitude of the angle included by the sides forming the knife-edge.
(2) initial width of knife-edge.
(3) hardness of material.

Character of Deformation of Pivots and Bearings

The deformation of a pivot and its opposing bearing under load may be either elastic or plastic, depending upon the magnitude of the load, the physical properties of the material, and the proportions of the specimens.

No knife-edge can remain perfectly sharp under load, and permanent set begins at very small loads. This is plastic deformation. When the pivot has a finite width of edge, the deformation will be elastic up to a certain load, after which it will be plastic. The load at which the deformation becomes plastic is designated in the report as the critical load. Quantitatively, the critical load, as determined by the change in width of edge of the pivot, is arbitrarily taken as the load that produces a change in width of 0.0005 in., and, as determined by the vertical deformation, is taken as the load corresponding to the point on the load-deformation curve at which the relation between load and deformation changes, that is, the break in the curve.

Conclusions

The tests reported seem to support the following conclusions relative to the critical loads for pivots of carbon and alloy tool steel when hardened and tempered:

(Note.—In American practice, specifications require that pivots and bearings of large-capacity scales be made of one or the other of two materials, namely, either high carbon tool steel or an alloy known to the trade as "special alloy pivot steel". The "alloy tool steel" studied in the investigation is not the alloy steel specified for scale pivots and bearings.)

(1) The critical load for a pivot varies approximately with the included angle of the faces forming the knife-edge for angles from 30° to 120°, the range covered by the tests.

(2) The critical load for a pivot varies approximately with the width of edge for widths from 0.004 in. to 0.040 in., the range covered by the tests.

(3) The critical load for a pivot increases with the hardness for variations from 45 to 60 on the Rockwell "C" scale, but no very definite relation between the two variables was established by the tests.

(4) In order that a pivot may not indent the bearing, the latter should be harder than the former by from 3 to 5 points on the Rockwell scale. There is some evidence indicating that permanent set is more likely to be received at a smaller load by the bearing than by the pivot if the latter has a wide edge and a large angle than if the pivot has a narrow edge and a small angle.

(5) The width of the edge of a pivot originally sharp will increase with the load, but, a load having been once applied, no further change by plastic flow is produced by successive applications of the same or smaller loads (wear is neglected), but a load greater than any previously applied will increase the set until the edge is wide enough to carry this new load.

(6) A load greater than the critical load will widen the edge of a pivot by plastic flow at the first application, but additional applications of the same load will not cause additional flow.

(7) The average unit normal pressure over the area in contact for 90° pivots having a hardness represented by Rockwell numbers of from 50 to 60 is about 400,000 to 500,000 lb. per sq. in. at the critical load. This corresponds to a critical load of from 4000 to 5000 lb. per lin. in. for an edge 0.01 in. wide. The unit normal pressure at the critical load does not seem to be affected by the initial width of edge, but it increases with the pivot angle and the hardness of the material.

Note.—No pivot of the many scores tested was chipped or nicked as a result of the tests. A hair crack was discovered in the edge of pivots having round edges in two instances, the pivots in both cases having been loaded to 30,000 lb. per lin. in. or more.

The above seven conclusions are stated in the report. The point as to whether or not the values of 5000 to 6000 lb. per lin. in. used in American design practice for high carbon tool steel pivots are proper is not covered in the report by specific mention. The data, however, do adduce that if the knife-edges are originally 0.01 in. or more wide, and the pivots are hardened to Rockwell 60, other than elastic deformation may not be expected if the load per linear inch does not exceed the design figures quoted. As stated above in the note preceding the first conclusion quoted from the report, the investigation did not cover "special alloy pivot steel".

Your Committee welcomes the investigation referred to herein and the publication of its results as greatly needed contributions to the art of scale design. It is believed that additional benefit would accrue from further study of the subject along the lines followed by the Engineering Experiment Station of the University of Illinois.

Appendix H

(10) BIBLIOGRAPHY OF RAILWAY STATIONS, YARDS, MARINE TERMINALS AND RAIL-AIR TRANSPORT

Compiled by E. E. R. Tratman.

(A) PASSENGER STATIONS AND TERMINALS

1. Passenger Stations

Baltimore—Pennsylvania R. R.—Railway Age, 1931, June 6, page 1104.

Boston—Boston & Maine R. R., revision of North station terminal yards—Engineering News-Record, 1931, November 5, page 718.

Boston—South Station; removal of trainshed—Engineering News-Record, 1931, July 30, page 177.

Buenos Aires—Stations and subway—Engineering News-Record, 1931, June 4, page 923.

Chicago—Illinois Central R. R., suburban station—Engineering News-Record, 1931, September 3, page 360.

Cincinnati—New union station—Civil Engineering, 1931, February, page 420. Engineering News-Record, 1931, Feb. 5 and 26, pages 248, 346, 348. Railway Age, 1930, October 25, page 873; 1931, March 7, 490.

Cleveland—Union station and subway connection—Civil Engineering, 1930, November, page 77. Engineering News-Record, 1931, July 23, page 140. Railway Electrical Engineering, 1930, July.

Columbus—Union station and grade separation—Engineering News-Record, 1931, August 20, page 284.

Dayton—Union station and grade separation—Engineering News-Record, 1931, September 17, page 449.

Hamilton—Canadian National Ry. and Toronto, Hamilton & Buffalo Ry.—Canadian Railway and Marine World; 1931, April, page 197, and 1930, October, page 631.

Mandan—Northern Pacific Ry.—Railway Age, 1931, January 24, page 227.

Milan (Italy)—New Central station—Railway Gazette, (London), 1931, September 11, page 331.

Milwaukee—Rapid-transit subway station—Engineering News-Record, 1931, April 2, page 552.

Milwaukee—Union station project opposed—Milwaukee Engineering (Engineers Club of Milwaukee), 1931, January, page 5.

Minneapolis—Union station project and rerouting of railways—Bulletin of Minnesota Federation of Architectural and Engineering Societies, 1931, January. Railway Age, 1931, June 27, page 1264.

Montreal—Canadian National Ry. project—Canadian Railway and Marine World, 1930, October and December, pages 642 and 705; 1931, February, March, April and July, pages 99, 145, 218 and 457. Engineering News-Record, 1930, October 9, pages 560, 562; 1931, February 5, page 248. Railway Age, 1931, March 28 and July 4, pages 639 and 30.

Montreal—Canadian Pacific Ry.—Canadian Railway and Marine World, 1931, February, page 82. Railway Age, 1931, March 28, page 639.

New York—Grand Central station; signaling—Railway Age, 1931, May 2, page 856.

New York—Subway station at 42nd St.—Civil Engineering, 1931, April, page 607.

Newark—Pennsylvania R. R. station—Railway Age, 1931, June 6, page 1104.

Oklahoma City—New union station for Frisco and Rock Island lines—Railway Age, 1931, September 5, page 359.

Omaha—Union stations—Railway Age, 1931, January 10 and 17, pages 87 and 136. Engineering News-Record, 1930, September 25, page 499.

Paterson—New station for Delaware, Lackawanna & Western R. R.—Railway Age, 1930, October 25, page 876.

Philadelphia—Pennsylvania R. R.; new main line and suburban stations—Engineering News-Record, 1930, October 9, pages 560 and 565; 1931, February 5, page 249. Railway Age, 1930, Nov. 1 and 15, pages 922, 1032; 1931, June 6, page 1104.

Philadelphia—Reading Railroad—Railway Age, 1930, October 25, page 896.

Pittsburgh—Pennsylvania R. R., motor coach station—Railway Age, 1930, Nov. 22, page 1127.
Portsmouth—Norfolk & Western Ry.—Norfolk & Western Magazine, 1931, June, page 318.
St. John, N. B.—Canadian National Ry. and Canadian Pacific Ry.—Canadian Railway and Marine World, 1931, October, page 621.
St. Louis—Illinois Terminal R. R. (electric)—Engineering News-Record, 1931, May 21, page 857.
St. Louis—Union station; platform shelters—Engineering News-Record, 1930, October 16, page 617.
Shreveport—Louisiana & Arkansas Ry.—Railway Age, 1930, November 8, page 984.
South Bend—Union station and line relocation; New York Central and Grand Trunk—Railway Age, 1930, December 6, page 1214. Engineering News-Record, 1929, October 3, page 538.
Tokio—Station and rapid-transit subway—Engineering News-Record, 1930, October 23, page 655.
Toronto—Union station (old)—Canadian Railway and Marine World, 1931, February, page 69.
Tulsa—Union station—Railway Age, 1931, May 30, page 1063.

2. Passenger Terminals and Facilities

Clearing snow and weeds at terminals—Railway Age, 1931, October 10, page 542.
Coach Yards—Economics of good facilities—Railway Age, 1931, August 15, page 237.
Coach Yards—Icing cars; car-washing machines—Railway Age, August 15, page 238.
Coach Yards—Sanitation and water service—Proceedings, American Railway Engineering Association, 1931, pages 208, 429, 523 and 814; 1930, pages 464, 465 and 470. Railway Age, 1931, August 15, page 238.
Coordination of Passenger Terminals—By F. G. Jonah—Civil Engineering, 1931, January and June, pages 280 and 869. Engineering News-Record, 1930, October 9, page 578.
Elevators and Escalators—Proceedings, American Railway Engineering Association, 1931, pages 588, 593 and 767; 1930, page 1215.
Grade separation in relation to passenger terminals—Engineering News-Record, 1931, February 26, April 30 and August 20; pages 360, 731 and 284.
High cost of stations—Engineering News-Record, 1930, August 21 and October 9, pages 279 and 560. Railway Age, 1930, November 1, page 922.
Joint stations—(See Union Stations).
Minneapolis—Proposed rerouting of terminal lines—Bulletin of Minnesota Federation of Architectural and Engineering Societies, 1931, January. Railway Age, 1931, June 27, page 1264.
Motor Coach Station—Pittsburgh; Pennsylvania R. R.—Railway Age, 1930, November 22, page 1127.
Motor Coaches—Effect on railway traffic—Proceedings, American Railway Engineering Association, 1931, page 699.
Motor Coaches—Operation of railways—Railway Age, 1930, November 22, page 1127; 1931, March 28 and April 25, pages 633 and 820.
Parking automobiles at stations—Proceedings of American Railway Engineering Association, 1931, pages 209, 757; 1930, pages 775, 1759.
Platforms, clearance diagram—Proceedings of American Railway Engineering Association, 1931, pages 98 and 715; 1930, page 1229.
Platforms, precast concrete; Chicago Elevated Railway—Engineering News-Record, 1931, June 11, page 966.
St. Louis—Use of Municipal Bridge and East Side approaches by Terminal Railroad Association—Engineering News-Record, 1930, August 7, page 214; 1931, February 5, page 248.
Station Design and Union Stations—By A. J. Hammond—Civil Engineering, 1931, October, page 1176.
Station Tracks—Bumpers, sliding—Railway Age, 1930, December 20, page 1335. Engineering News-Record, 1931, January 22, page 154.
Station Tracks—Concrete floor—Proceedings, American Railway Engineering Association, 1930, page 608.

Station Tracks—Layouts for passenger stations—Engineering News-Record, 1931, February 26, page 346.

Tacoma—General terminal plan of 1911 and conditions in 1930—Civil Engineering, 1931, September, page 1105.

Union stations, agreement for operation—Proceedings of American Railway Engineering Association, 1931, pages 111 and 713; 1930, pages 493 and 1703.

Union Stations and Separate Stations—Civil Engineering, 1931, October, page 1176.

Water service for stations—Proceedings of American Railway Engineering Association, 1930, pages 464, 465, 470. Railway Age, 1931, August 15, page 238.

(B) FREIGHT STATIONS AND TERMINALS

3. Freight Terminals and Warehouses

Chicago—Chicago & Northwestern Ry.—Railway Age, 1931, May 30, page 1960. New terminal under Merchandise Mart Building—Railway Age, 1931, September 26, page 471.

Churchill—Hudson's Bay Railway—Canadian Railway and Marine World, 1931, June, page 407.

Jersey City—Erie R. R. pier—Engineering News-Record, 1931, March 26, page 510. Railway Age, 1931, February 14, page 358.

Jersey City—Pennsylvania R. R.—Engineering News-Record, 1931, January 15, page 123. World Ports, 1931, August, page 1104. Railway Age, 1931, October 24, page 631.

Los Angeles—Union Pacific R. R.—Engineering News-Record, 1931, May 28, page 905.

Minneapolis—Readjustment of terminals by re-routing railways—Bulletin, Minnesota Federation of Architectural and Engineering Societies, 1931, January. Railway Age, 1931, June 27, page 1264.

New York—Inland union freight station of New York Port Authority—Engineering News-Record, 1931, January 8, May 7 and September 17, pages 83, 781 and 465. Railway Age, 1930, October 25, page 871.

New York—West side terminal for New York Central R. R.—Engineering News-Record, 1931, February 5, page 248.

St. Louis—Illinois Terminal R. R.; electric—Engineering News-Record, 1931, May 21, page 857.

Vancouver—Canadian National Ry.; new pier—Engineering News-Record, 1931, May 7, page 779.

Express Terminal—Chicago & Northwestern Ry., at Chicago—Engineering News-Record, 1931, May 14, page 802. Railway Age, 1931, June 13, page 1149.

Express Terminals—At various cities—World Ports, 1930, June, page 547.

Produce Terminals—Baltimore; Baltimore & Ohio R. R.—Railway Age, 1930, October 4, page 719.

Produce Terminals—Detroit; joint use by Pennsylvania, Pere Marquette and Wabash railways—Railway Age, 1930, October 18, page 788.

Produce Terminals—Missouri Pacific R. R.—Railway Age, 1930, December 20, page 1306.

Produce Terminals—Montreàl; Canadian National Ry.—Canadian Railway and Marine World, 1931, September, page 585.

Produce Terminals—Philadelphia; Pennsylvania R. R.—Railway Age, 1929, January 12, page 137. World Ports, 1931, September, page 1233.

Produce Terminals—Toronto; Canadian National Ry.—Canadian Railway and Marine World, 1931, February, page 99.

Clearance diagram for freight house doors—Proceedings, American Railway Engineering Association, 1931, pages 97 and 98.

Container Service—Railway Age, 1930, November 22 and December 27, pages 1131 and 1422; 1931, July 4 and August 22, pages 2 and 275. Engineering News-Record, 1931, May 28, page 876. World Ports, 1930, December.

Container Service—Chicago & Northwestern Ry.—Railway Age, 1930, December 27, page 1422.

Container Service—Cincinnati & Lake Erie Electric Ry.—Railway Age, 1931, January 24, page 249.

Container Service—Pennsylvania R. R.—World Ports, 1930, December, page 145.

Elevators—Freight and Dock—Proceedings, American Railway Engineering Association, 1931, pages 593 and 767; 1930, page 1215. Engineering News-Record, 1931, March 26 and July 23, pages 510 and 137. Railway Age, 1931, February 14, page 358.

Freight Handling—Chicago, Milwaukee, St. Paul & Pacific Ry. pier—Railway Age, 1931, September 12, page 405.

Freight Handling—Delaware, Lackawanna & Western R. R. freighthouse—Railway Purchases and Stores, 1931, August, page 383.

Freight Handling—Power trucking—Railway Age, 1931, March 28 and August 29, pages 631, 314, 317 and 335; September 26, page 466.

Freighthouse design—Proceedings, American Railway Engineering Association, 1931, page 548.

Industry Tracks; records of—Proceedings, American Railway Engineering Association, 1930, page 925.

Motor Trucks; effect on railway traffic—Railway Age, 1931, March 28, page 636. Proceedings of American Railway Engineering Association, 1930, pages 778 and 1760; 1931, page 699.

Motor Trucks;Road-Rail Transfer system—Railway Age, 1931, May 2, page 863.

Passing Sidings; economics of proper location—Proceedings, American Association of Railroad Superintendents, 1931. Railway Age, 1931, July 4, page 19.

Passing Sidings; improvements on St. Louis-Southwestern Ry.—Railway Age, 1930, November 22, page 1071.

Store-door System; railway collection and delivery—Proceedings, American Association of Railroad Superintendents, 1931. Proceedings, American Railway Engineering Association, 1931, page 700. Railway Age, 1930, November 22, pages 1128 and 1133; 1931, March 28, August 15 and 29, pages 639, 255 and 293. Engineering News-Record, 1931, May 28, page 875.

Store-door service—Chicago & Northwestern Ry.—Railway Age, 1931, May 30, page 1060.

Store door service—Pacific Fruit Lines—Railway Age, 1930, November 22, page 1137.

Store-door service—Southern Pacific Railway—Railway Age, 1930, December 27, page 1423.

Store-door service—Texas & Pacific Ry.—Railway Age, 1931, February 28, page 436.

Terminal Structures; maintenance rules—Proceedings, American Railway Engineering Association, 1931, page 140.

4. Freight Yards and Yard Facilities

Chicago—Chicago & Northwestern Ry.; Proviso yard—Railway Purchases and Stores, 1931, September, page 416.

Chicago—Illinois Central R. R.; Markham yard; location of water stations—Proceedings, American Railway Engineering Association, 1930, page 434.

Columbus—Norfolk & Western and Pennsylvania yard improvements—Engineering News-Record, 1931, August 20, page 284. Railway Age, 1931, September 12, page 391.

Fresno—Southern Pacific Ry. yard and fruit terminal—Railway Age, 1930, December 13, page 1268. Engineering News-Record, 1929, July 18, page 89.

Marion—Erie R. R.—Railway Age, 1931, April 11, page 706.

Texas & Pacific R. R.—Revision of yards—Railway Age, 1930, October 25, page 849.

Toledo—New York Central R. R.; coal dock and car dumper—Civil Engineering, 1930, November and December, pages 99, 103, 206, 207. Engineering News-Record, 1930, July 17, page 100. Railway Age, 1930, February 15 and November 29, pages 439 and 1165.

Tyler—St. Louis Southwestern Ry.—Railway Age, 1930, November 22, page 1074.

Vancouver—Canadian Pacific Ry.—Canadian Railway and Marine World, 1931, February, page 86.

Air-pipe lines in yards—Proceedings, American Association of Railroad Superintendents, 1931. Railway Age, 1930, August 30, page 428; 1931, July 4, page 17.

Bumpers—Sliding bumpers in European yards—Engineering News-Record, 1931, January 22, page 154. Railway Age, 1930, December 20, page 1335.

Car dumpers—Coal-car dumpers at Toledo, New York Central R. R.—Civil Engineering, 1930, November and December, pages 99, 103, 206, 207. Railway Age, 1930, February 15 and November 29, pages 439 and 1165, Engineering News-Record, 1930, July 17, page 100.

Car dumpers—Grain-car dumper at Philadelphia, Reading R. R.—World Ports, 1931, page 1237.

Car dumpers—Scales for—Power, 1930, February 11, page 204. Iron Age, 1931, April 9.

Car retarders—Advantages, disadvantages and economy in yard operation—Proceedings, American Railway Engineering Association, 1930, page 781; 1931, page 212. Railway Age, 1931, July 4 and August 1, pages 18 and 160. Proceedings, American Association of Railroad Superintendents, 1931.

Car retarders—Relations to yard grades—Proceedings, American Railway Engineering Association, 1930, page 781; 1931, page 212.

Car retarders—On car dumper; empty car track—Power, 1930, February 11, page 204.

Car retarders—Westinghouse-Saxby eddy-current device in European experiments—Railway Gazette (London), 1931, June 12, page 866. Engineering News-Record, 1931, October 8, page 576.

Clearing snow and ice—Railway Age, 1931, October 10, page 542.

Design and operation of freight yards—Proceedings, American Railway Engineering Association, 1931, pages 210, 646, 651, 658; 1930, pages 781 and 1014.

Drainage of yards—Railway Age, 1930, October 4, page 709. Proceedings, Roadmasters Association, 1930, page 95.

Engine washing platforms—Proceedings, American Railway Engineering Association, 1931, page 484.

Flood Lighting—(See Lighting).

Hump and Flat Switching—Grades, car resistance, track layout—Proceedings, American Railway Engineering Association, 1931, pages 210, 211, 693, 695, 758; 1930, page 1014.

Icing fruit trains—Southern Pacific Ry.—Railway Age, 1930, December 13, page 1268.

Interchange—Car transfers and delays to transfer engines—Railway Age, 1931, March 14 and July 4, pages 532, 17 and 18. American Association of Railroad Superintendents, 1931.

Lighting—Proceedings, American Railway Engineering Association, 1930, pages 1445, 1818; 1931, page 213.

Oiling car journals and wheel flanges—Proceedings, American Railway Engineering Association, 1931, page 213.

Radio-telephone yard orders—Proceedings, American Railway Engineering Association, 1931, pages 700 and 834; 1930, page 1027.

Switching engines—Handling foreign transfer engines in interchange service—Railway Age, 1931, March 14 and July 4, pages 532, 17 and 18. Proceedings, American Association of Railroad Superintendents, 1931.

Switching engines—Oil and electric power—Railway Age, 1930, November 22 and December 13, pages 1118 and 1265. Railway Age, 1931, October 24, page 620. Proceedings, American Railway Association (Motor Transport Section), 1930.

Track scales; for car-dumpers—Commonwealth-Edison Co. plants—Power, 1930, February 11, page 204. Iron Age, 1931, April 9.

Track Scales; for industrial plants—Proceedings, American Railway Engineering Association, 1930, pages 790 and 1761.

Track scales; maintenance rules, master scales and test cars—Proceedings, American Railway Engineering Association, 1931, pages 141, 214, 760.

Triple-crew yard operation—Proceedings, American Association of Railroad Superintendents, 1931. Railway Age, 1931, July 4, page 17.

Water stations in yards—Proceedings, American Railway Engineering Association, 1930, page 434.

(C) RAIL-AND-WATER TERMINALS

5. Ports and Harbors

Baltimore—Civil Engineering, 1931, June, page 805. World Ports, 1930, September, page 645.

Cincinnati—World Ports, 1930, March, page 684.

Hampton Roads—Civil Engineering, 1931, June, page 808.

Jersey City—Erie Railroad piers with elevators—Engineering News-Record, 1931, March 26, page 510. Railway Age, 1931, February 14, page 358. Engineering News-Record, 1931, January 15, page 123. Railway Age, 1931, October 24, page 631.
Jersey City—Pennsylvania R. R.—World Ports, 1931, August, page 1104.
Lake Charles—Engineering News-Record, 1931, May 7, page 773.
Milwaukee—World Ports, 1930, page 853.
Mobile—World Ports, 1930, November, page 13.
New York—Car ferries—Railway Age, 1931, March 7, page 505.
Philadelphia—Baltimore & Ohio, Pennsylvania and Reading railroads—World Ports, 1931, September.
Peoria—Illinois River—Engineering News-Record, 1931, July 9, page 49.
Portland, Me.—Engineering News-Record, 1931, August 13, page 258. World Ports, 1931, June, page 875.
Port Newark—World Ports, 1931, September, page 1287.
Quebec—Canadian Pacific Ry.—Railway Age, 1931, June 27, page 1228. Canadian Railway and Marine World, 1931, July, page 423.
Seattle—Canadian Pacific Ry.—World Ports, 1930, page 947.
Tacoma—Civil Engineering, 1931, September, page 1105.
Vancouver—Canadian National Ry. pier—Engineering News-Record, 1931, May 7, page 779.
Wilmington, Del.—World Ports, 1931, September, page 1267.

6. Car Ferries and Terminal Facilities

Car Ferry—Frankfort, Mich.; harbor extension—Engineering News-Record, 1931, June 18, Page 1017.
Car Ferry—Mackinaw City, Mich.—Dock with elevators for handling automobiles—Engineering News-Record, 1931, July 23, page 137.
Car Ferry—New Orleans; for Texas & Pacific Ry.—Railway Age, 1930, October 18, page 787.
Car Ferry—New York harbor—Railway Age, 1931, March 7, page 505.
Car Ferry—St. Lawrence, Canadian Pacific Ry.—Canadian Railway and Marine World, 1931, January, page 54.
Elevators—Dock, for handling automobiles and freight—Engineering News-Record, 1931, March 26 and July 23, pages 510 and 137. Railway Age, 1931, February 14, page 358.
Handling cars at ports—Railway Age, 1931, May 2, page 855.
Handling freight by skids and trucks—Railway Age, 1931, September 12, page 405.
Mechanical equipment for marine terminals—World Ports, 1930, page 619.
Mississippi River barge line—Civil Engineering, 1931, January and July, pages 253 and 947.
Public ownership of marine terminals—World Ports, 1931, July.
Railroad marine terminals; design—Railway Purchases and Stores, 1931, August, page 380.
Waterways and rail transportation—Railway Age, 1930, page 1077.

(D) AIRPORTS AND RAIL-AIR TRANSPORTATION

7. Airports

Airports—City location—Civil Engineering, 1931, January and June, pages 280, 869.
Airports—Coordination with railways—Engineering News-Record, 1930, October 9, page page 578. Civil Engineering, 1931, January and June, pages 280, 869.
Airports—Detroit, city and county—Engineering News-Record, 1931, June 18, page 1006.
Airports—London, England—Paper project for a wheel-shaped port built over a railway terminal and supported by 10-story buildings—Modern Transport (London), 1931, June 13.
Airports—Milwaukee; in close relation to Chicago & Northwestern Ry. station—Milwaukee Engineering (Engineers Society of Milwaukee), 1931, January, page 5.
Airports—Paving—Engineering News-Record, 1931, January 29, page 189.

8. Rail-Air Service

Air-rail transport lines—Railway Age, 1929, July 13, page 138; 1930, February 8, July 19 and November 15, pages 406, 129, 1017 and 1046; 1931, August 15, page 255.

Air-rail transport—Relation to railway traffic—Proceedings, American Railway Engineering Association, 1931, page 699. Railway Age, 1930, November 15, page 1047; 1929, April 6, page 769.

Air-rail service—Boston & Maine R. R.; Boston to Portland—Railway Age, 1931, July 25, page 32.

Air-rail service—Chicago & Alton R. R.—Railway Age, 1931, July 4, 1928.

Air-rail service—Chicago & Northwestern Ry.—Railway Age, 1929, April 27, page 984; 1930, July 19, page 128.

Air-rail service—Chicago Great Western Ry.—Railway Age, 1929, April 13, page 864.

Air-rail service—Chicago and New York to Los Angeles—Railway Age, 1931, June 15, page 1391; 1929, July 13, page 174.

Air-rail service—Mexico connection—Railway Age, 1929, September 7, page 614.

Air-rail service—Missouri Pacific Ry.—Railway Age, 1929, April 20, page 928.

Air-rail service—Monon Line; C., I. & L. Ry.—Railway Age, 1930, June 7, page 1392.

Air rail service—New York Central R. R.—Railway Age, 1931, July 4, page 29.

Air-rail service—Southwest line—Railway Age, 1930, May 3, page 1088.

Air-rail service—Spokane to New York—Railway Age, 1930, August 2, page 258.

REPORT OF SPECIAL COMMITTEE ON STANDARDIZATION

J. C. Irwin, *Chairman;*
Louis Yager, *Vice-Chairman;*
H. Austill,
C. W. Baldridge,
R. C. Bardwell,
E. H. Barnhart,
F. L. C. Bond,
J. G. Brennan,
W. J. Burton,
A. P. Crosley,
Robert H. Ford,
P. M. Gault,
E. A. Hadley,
C. C. Haire,
C. R. Harding,
J. R. W. Ambrose, *Vice-Chairman;*
M. Hirschthal,
L. P. Kimball,
C. R. Knowles,
F. R. Layng,
F. L. Nicholson,
H. L. Ripley,
F. C. Shepherd,
A. L. Sparks,
Earl Stimson,
J. E. Teal,
F. M. Thomson,
A. R. Wilson,
S. Withington,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents the following report:

In previous reports of this Committee it has been pointed out that the primary influence of this Association toward the economies and conveniences of Standardization will be through the interest of its members in the use of the Recommended Practices in the Manual. The endorsement and approval by the American Railway Association is of special significance as indicating recognition of the value of the expert skill and judgment by which the Manual has been developed and the importance of securing the greatest benefit from it by the application of its principles to work leading to Simplified Practice and Standardization.

Men trained in the work of this Association are collaborating with those from other Sections and Divisions of the American Railway Association together with men assigned by associations of all sorts of united industries and by Departments of the National Government in the creation of "American Standards" through the fundamental work in the Sectional Committees of the American Standards Association, thus carrying the influence of the A.R.E.A. into the entire field having common interests in the projects under study.

It is recognized that standards are not frozen or unchangeable. A Standard can remain a Standard only so long as it represents the best practice in the light of present knowledge. However, in order to maintain the value of standards, revisions should be made by the same agencies that create them, otherwise there will be a return to original chaotic conditions which brought about the creation of the standards.

One of the greatest Standardization bodies is the National Bureau of Standards, a branch of the United States Department of Commerce. In its publication "Commercial Standards Monthly" it prints in a conspicuous place, the following statement:

> "Standardization is a continuing process—its aim is not fixity or stagnation but to add serviceability as often as the potential gain makes it worth while."

The Committees of the A.R.E.A. are charged with the responsibility of keeping its Recommended Practices up to date. In order to do so intelligently, their members must keep informed on progress in the state of the art in any direction affecting the subject under study. It is especially important that men assigned to Sectional Committees of

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the American Standards Association be members of the Committees of the A.R.E.A. having similar subjects under their charge so that there will be perfect collaboration between the two Committees. This can be secured only by each Committee being completely informed on the activities of the other and by agreement on various matters as work progresses, before views become so divergent that they cannot be brought together.

Standards created and revised through these authorized agencies are highly co-operative through the collaboration of skilled representatives and, in order to secure wide economic benefits, they must be largely relied on.

Meeting of this Committee with Representatives of the National Bureau of Standards and the Federal Specifications Board

The work being done by the United States Government in the line of Standardization and Simplified Practice has assumed very large proportions and, in order to give the members of this Committee and, through them, the members of all Committees of which they are Chairmen, the opportunity for contact with the government agencies which are making progress along these lines in co-operation with industrial and scientific bodies and, at the same time, to draw the special attention of these government agencies to the activities of our own Association, a meeting of this Committee was held at the National Bureau of Standards, Washington, D. C., May 22, 1931. This meeting was attended by twenty-three A.R.E.A. men among whom were four members of the Board of Direction and the Secretary of the Association. It was addressed by the heads of six branches of the Government Bureaus, as shown in the following condensed program.

Address of Welcome—George K. Burgess, Director, National Bureau of Standards.

Research Associate Plan—Research and Testing Activities of the National Bureau of Standards—Dr. L. K. Briggs, Assistant Director for Research and Testing.

Preparation and Promulgation of Federal Specifications—Captain J. H. Fellows, Vice-Chairman, Federal Specifications Board.

Services of the Division of Simplified Practice—E. W. Ely, Chief.

Services of the Division of Specifications—Dr. A. S. McAllister, Chief.

Services of the Division of Trade Standards—I. J. Fairchild, Chief.

Following the addresses there was a tour through the laboratories during which explanations were made by those in charge of tests.

Simplified Practice

There are special opportunities for economies in the railway field by attention to Simplified Practice or "Simplification" by the elimination of unnecessary or uneconomical types, sizes and grades of material. A reduction of varieties reduces the amount of money tied up in stock, saves waste from obsolescence and effects economies in production, purchasing and handling by reason of the larger quantities of the remaining selected varieties required.

Dr. Julius Klein, Assistant Secretary of Commerce, is quoted in "Railroad Data" as describing Simplified Practice as "that policy by which manufacturers, distributors and users, through voluntary agreement, limit the usually made and sold varieties of any given manufactured articles to such convenient minimum as will satisfy all normal and reasonable demands." It also states that he has estimated the savings by all industry as a result of simplified practice at an average of more than one quarter of a billion dollars annually.

Much progress has been made by individual railways analyzing their stores and eliminating unnecessary varieties, but there is still a very large field for co-operation

between the railways and industries in the study of supplies with a view to simplification and standardization.

The Division of Simplified Practice of the National Bureau of Standards, U. S. Department of Commerce, is maintained for the purpose of fostering this work. Its function is to bring together all parties interested in a project of this character and to aid in co-ordinating their work in developing a simplified practice recommendation. Its services are available for the study of any project.

It publishes a list of projects proposed, approved and accepted by industrial groups. The issue of September 1st, 1931 lists "Simplified Practice Recommendations Now in Effect" for 121 commodities in which varieties have been greatly reduced.

Striking examples are as follows:

S.P.R. No.	*Item*	*Reduction in Varieties From*	*To*	*Per cent Reduction*
1–29	Vitrified Paving Brick	66	6	91
3–28	Metal Lath	78	4	95
7	Rough and Smooth Face Brick	75	2	97
	Common Brick	44	1	98
9–28	Woven Wire Fencing	552	62	88.7
	Woven Wire Fence Pkgs	2,072	117	93.4

It is obvious that the higher the adherence to each simplification the greater will be the economies for all concerned.

An article by Edwin W. Ely, Chief of the Division of Simplified Practice, written by him in response to a request from your Chairman for condensed information on this subject is presented as an Appendix to this report.

The work of the American Standards Association leads largely to simplification. Conspicuous examples of what has been done by the co-operation of the railways and the manufacturers or producers in this line are the items of "Cross Ties and Switch Ties", A.S.A. project 03–1926, and "Track Bolts and Nuts", A.S.A. Project B 18d–1930. These projects were sponsored by the A.R.E.A. and its representatives had a large part in the work.

AMERICAN STANDARDS ASSOCIATION (A.S.A.)

A.R.A. Representation in A.S.A.

L. A. Downs, President, Illinois Central System, Past-President A.R.E.A., continues as the member of the Board of Directors, American Standards Association, designated by the American Railway Association.

Prior to this year (1931) the only Representative and Alternates of the A.R.A. in the A.S.A. were from Division IV—Engineering. On account of the increased appropriation of the A.R.A. to assist in the work of the A.S.A. mentioned in this Committee's report last year, arrangements were made to appoint two more Representatives from other Divisions of the A.R.A. together with additional Alternates from Divisions or Sections not otherwise represented.

The personnel is now as follows:

From Division IV—Engineering: Representative, J. C. Irwin (term expires December 31, 1933)
Alternates—J. R. W. Ambrose
E. K. Post
J. S. Hagen (Electrical Section)
J. E. Saunders (Signal Section)

From Other Divisions

Division V—Mechanical; Representative, F. H. Hardin (term expires December 31, 1932).

Division I—Operating; Representative, W. Rogers (Tel. & Tel. Sec.) (term expires December 31, 1931).

Division VI—Purchases and Stores, Alternate, L. C. Thomson.

Members of Sectional Committees of the A.S.A. assigned from the A.R.E.A. and also from other Sections or Divisions of the A.R.A. are shown under the list of projects now under study on pages following. These are the men who are co-operating with those assigned from other organizations to do the fundamental work leading to the creation and recommendation of standards to be submitted to the Standards Council for approval.

The American Standards Year Book which lists the complete personnel on many of these projects can be obtained on application to the office of the American Standards Association, 29 West 39th Street, New York City.

Withdrawal of Steel Railway Bridge Specification Projects

In July 1931, on recommendation of Committee XV—Iron and Steel Structures, the A.R.E.A. withdrew its sponsorship of the following A.S.A. projects:

A3a—Specifications for Steel Railway Bridges
A25—Specifications for Movable Railway Bridges

These projects had been submitted by the A.R.E.A. May 23, 1923, for consideration as American Standards. On October 17, 1923, the American Society of Civil Engineers submitted specifications for Design and Construction of Steel Railway Bridge Superstructures for consideration as American Standard.

On December 3, 1923, a "Special Committee" was designated by A.E.S.C. (now A.S.A.) to consider the two sets of specifications with the view of recommending either as "Standard." After numerous meetings, this Special Committee finally reported inability to reach an agreement.

On February 15, 1925, the Committee on Iron and Steel Structures which had formulated the two specifications of the A.R.E.A., adopted a resolution recommending that a "Conference Committee" composed of representatives of the American Society of Civil Engineers and of the A.R.E.A. be formed for the purpose of harmonizing existing specifications for steel railway bridges and, if possible, recommend a single specification, to be later submitted to American Standards Association for approval as "Standard". This Conference Committee was created May 27, 1925, and was composed of three representatives of each of the two organizations concerned.

As a result of four years' labor, the Conference Committee prepared a draft of "General Specifications for Steel Railway Bridges" which was promulgated March, 1929. This joint specification was referred to the Committee on Iron and Steel Structures for consideration and recommendation.

After due consideration, the Committee on Iron and Steel Structures unanimously concluded "that these specifications are not adapted to the requirements of the A.R.E.A. for the design and construction of steel railway bridges, and recommends that no action be taken toward having these or any other specifications for steel railway bridges adopted as 'American Standard' ".

On July 6th, 1931, your Representative in the A.S.A. (your Chairman now reporting) was instructed to withdraw the submission of these projects to the A.S.A. July 21st, 1931, the sponsorship of these projects and the Specifications submitted under them by the A. R. E. A. were formally withdrawn and at the regular meeting of the Standards Council, September 10, 1931, final action on their withdrawal was taken.

Other Subjects for Standardization

The A.R.E.A. has not submitted any new projects to the A.S.A. during the year but some subjects have been suggested for consideration by this Committee with a view to possible recommendation to the Board of Direction for submission to the A.S.A. The suitability of these subjects for national standardization and their relation to projects already under way will be studied by this Committee.

Electrical Standards Committee (E.S.C.)

During the year, the American Institute of Electrical Engineers requested the Electrical Advisory Committee of the A.S.A. to draw up plans for organization of a joint agency in the electrical industry functioning as an integral part of the A.S.A. for the purpose of carrying out the standardization activities of the electrical industry. As a consequence a Sub-Committee of the Electrical Advisory Committee was appointed to formulate a Constitution along the lines suggested. The revised organization and the Constitution have been accepted by all National organizations concerned and have been approved by the Board of Directors A.S.A.

The purpose of the E.S.C. as outlined in the Constitution is "to provide a single central Standardizing Committee within the field of the electrical industry, both in the United States and in contact with international standardization for the development of American Standards for the electrical industry under the authority of organizations duly represented in E.S.C. and of the American Standards Association subject to the Constitution, By-Laws and Procedure of the American Standards Association."

Sidney Withington has been designated the Representative of the A.R.A. on the E.S.C.

CANADIAN ENGINEERING STANDARDS ASSOCIATION (C.E.S.A.)

Railway Personnel

Members of the Main Committee of this Association who are members of the A.R.E.A. are as follows:

F. L. C. Bond, Canadian National Railways
J. M. R. Fairbairn, Representing Institute of Civil Engineers
Lt. Col. C. N. Monsarrat, Consulting Engineer, Montreal
T. L. Simmons, Board of Railway Commissions for Canada
A. F. Stewart, Canadian National Railways

The Canadian Pacific Railway is also represented by J. A. Shaw.

Both Industrial Standardization and Simplified Practice are handled by the C.E.S.A. Its Year Book and Bulletins are available on application to its office, 46 Elgin Street, Ottawa, Ontario.

Your Committee directs your attention to previous reports for information in regard to the organization and activities of various national and international standardization bodies.

Accompanying this report are appendices as follows:

(A) Article on "Simplification in the Railway Field," by Edwin W. Ely.

(B) American Standards Approved by the American Standards Association, September 1, 1930 to September 1, 1931.

(C) American Standards Association Technical Projects on which the Railway Associations are Now Co-operating.

Respectfully submitted,

Special Committee on Standardization,

J. C. Irwin, *Chairman.*

Appendix A

SIMPLIFICATION IN THE RAILWAY FIELD

Edwin W. Ely
Chief, Division of Simplified Practice, National Bureau of Standards, U. S. Department of Commerce.

Simplification consists in reducing unnecessary variety. Such variety may exist in size, type, composition, quality, method, process or any other feature or function of a commodity or activity. In applying simplification, the first essential is to define "unnecessary" in respect to the particular item in which variety is considered excessive. In the vast majority of cases the best measuring stick is that of demand, or quantity of use. Data on quantity of use are usually easy to obtain, thereby eliminating from consideration any question of personal opinion. Simplification may be applied by an organization to its own products or to commodities which it buys. When applied throughout an entire industry, with the cooperation of all elements in that industry, this activity has become known as simplified practice.

Although the principles of simplification have been applied as long as industry has existed, the railways were among the first to develop true simplified practice. One of the most striking applications may be found in the development of standard gauge of track. In this instance, as in all true simplification jobs, the purpose of the application was primarily commercial. The objective was uniformity, to provide interchangeability in the use of rolling stock, thereby making inter-line business and car exchanges possible. Other developments toward the same end include coupler height and design.

As long ago as 1882, the Master Car Builders' began to apply simplification to axles, journals, and many other mechanical elements, greatly reducing the variety which once existed. In the case of journal boxes, for example, the variety was reduced from 58 to 6 types, a reduction of 93 per cent, during the period from 1882 to 1921. The variety of brake-shoes and brake-heads was similarly reduced during the same period to one type, a reduction of 96 per cent. Many of the early simplifications carried through by the railways have been in effect so long that the former diversity has been almost forgotten.

In addition to the work done by the various Divisions of the American Railway Association and their predecessors, great progress has been made by certain individual railways in reducing the variety of items in the supply departments. It is only within comparatively recent years that the cost of handling excessive inventories has been realized, either in the transportation field or in general industry. This has been partly due to lack of uniformity in cost accounting, which in itself offered a fertile field for simplification, meaning reduction in variety of method. Excessive variety inevitably means buying, storing and handling many items which move very slowly or which are in small or irregular demand. Any reduction in variety, as for example the establishment of 12 stock sizes of a certain type of bolts instead of 100, saves money all the way from the original purchase requisition to the final use of the material. It means fewer purchase orders, each one for larger quantities; less accounting and clerical work throughout; less space required for storage at all points, and less difficulty in separating and classifying items; lower handling costs in most cases; reduction in obsolescence; and reduced interest, depreciation, and other overhead charges. Some large railways have succeeded in reducing the total number of different items of inventory more than 40 per cent, and reducing the average inventory in dollars as much as 70 per cent.

Among items simplified are the following:

Item	*Per cent Reduction in Variety*
Angles, structural	50
Bar Iron and Steel	86
Bolts, Carriage	83
Bolts, Machine	—
Bolts, Stay	61
Brass and Copper Tubes	38
Brass and Copper Sheets	36
Channels, Structural	68
Circular Saws	63
Curtain Material	50
Curtain Rollers	33
Finished Car and Locomotive Parts	36
Fire Box Steel Plates	11
Fire Brick	59
Lag Screws	—
Lumber, Rough and Surfaced	24
Non-ferrous Rods and Metals	32
Paints and Varnishes	22
Powdered Emery	75
Rivets	63
Rough Iron and Steel Castings	46
Sheet Steel	75
Spring Steel, Flat	44
Steel Plates	11
Tires	—
Tubes, Boiler Superheater	65
Wood Screws	—

In regard to direct savings in the cost of commodities purchased, the adoption of a simplified line of items by an entire industry, such as the railways, is immediately reflected in decreased costs to the supply manufacturer, as well as other advantages which will be obvious. If a supply firm, for example, knows that during a given period all railways will order only twelve different sizes of a certain type of bolt, he can stabilize his production, cut manufacturing costs, inventories, and many other costs. In any highly competitive industry, such as the railway supply business, such savings are sure to be reflected in selling prices. While a single railway, particularly a large system, can accomplish much by simplifying its own line of stores and supplies, much more can be accomplished if all railways reach an agreement as to simplified lists of ordinary commodities regularly purchased. This applies even more to small quantity than to large quantity orders. There are many items which no one railway buys in sufficient quantities to permit a manufacturer to apply mass production methods to it. If, however, this same commodity is bought by all the other roads, in the same minimum range of sizes and types, the total quantity may be great enough to enable the manufacturer to make substantial reductions in cost. Even in the items which are purchased in considerable quantities the same principle applies, though perhaps in lesser degree.

In the case of a certain electrical supply item, the manufacturers found that seven sizes out of sixty were carrying 82 per cent of the total demand. This item comes in progressive sizes, and prices progress by more or less uniform increments from the smallest to the largest size. Item No. 9, however, might be regularly produced in lots of 1,000; Item No. 10, slightly larger, in lots of more than 100,000. Its actual cost was materially less than that of No. 9, but its price was higher because it was slightly larger in size. This product is typical of an enormous number of common articles, in which

the excess cost of the sizes infrequently demanded is borne by the item in large and regular demand. The manufacturers of this product decided to list only the seven important sizes as "stock" items, stating that all other sizes would be furnished only on special order. A special order meant a special price, and probably slower delivery. Purchasing agents naturally avoided these specials, and within a relatively short time demand for them almost disappeared, to the great benefit of both manufacturers and users.

In the railway field, as in other industries, simplification can be applied not only to the actual articles or commodities bought and handled, but to the equipment and methods used in connection with storing, handling, and distributing them. To mention only one class of equipment, certain railways have adopted a minimum number of standard sizes for skid platforms, lift trucks, trailers and tractors. This has resulted in enormous savings in the cost of handling and rehandling a large proportion of stores.

Simplification can also be applied to great advantage in sizes and types of packages or other containers used for small parts.

In the general industrial field, simplification has been applied to a great number of commodities, produced by hundreds of industries. In each case the basic principles and methods have been the same. First, production has been surveyed and quantities tabulated to show the number of sizes or kinds produced during a period of at least one year. In almost every case it has been found that 80 per cent or more of the demand was concentrated on less than 20 per cent of the varieties made. In many cases these percentages have been even farther apart. For example, a survey showed 42,877 catalogued sizes of solid section steel windows. Ninety-five per cent of production was concentrated on 2,274 sizes, about 5 per cent of the total. No one manufacturer catalogued the full line, but from the viewpoint of the user the situation was just as bad as though every manufacturer made every size. Similar conditions have been found in hundreds of other industries, and remedied by simplification through cooperative effort by manufacturers, distributors and users.

A simplification project is usually initiated by one group in an industry. Outside of the transportation field and one or two others, the initiative usually comes from the manufacturers of the product. There have, however, been many cases in which the users initiated a project, and some cases where it was initiated by distributors. It is immaterial which group initiates such a project, so long as that group has at hand the necessary data for making a complete survey of demand. In the case of railway stores and supplies, etc., the railways themselves have the necessary data available. Through the various Divisions of the American Railway Association these data can be tabulated and the real situation easily and quickly determined.

In cases where a number of groups are directly concerned in a simplification program, the services of the Division of Simplified Practice of the National Bureau of Standards are available on a cooperative basis. This division functions merely as a centralizing and coordinating agency to assist in developing the best thought and practice in the industry. The division does not initiate simplification projects, nor does it attempt in any way to suggest definite things to be done. When one group in an industry, such as the railways for example, has agreed upon a specific simplification program, the Division of Simplified Practice will undertake to "sell" that program to the other interested groups, including manufacturers, supply houses, etc. It frequently happens that items regularly bought by the railways are also bought by other industries, in which case some neutral agency is desirable in order to assure cooperation between railways, other buyers, manufacturers, and dealers.

Appendix B

STANDARDS APPROVED BY THE AMERICAN STANDARDS ASSOCIATION

Period September 1, 1930, to September 1, 1931

ASA Symbol	*Title*	*Approved as*
A1a—1931	Standard Specifications for Portland Cement	American Standard
A1b—1931	Standard Methods of Testing Cement	American Standard
A17—1931	Safety Code for Elevators, Dumbwaiters and Escalators	American Standard
B9—1930	Safety Code for Mechanical Refrigeration	American Standard
B16b2—1931	Cast Iron Pipe Flanges and Flanged Fittings for Maximum Working Saturated Steam Pressure of 25 Lb. per Sq. In.	Amer. Tent. Std.
B17f—1930	Woodruff Keys, Keyslots and Cutters	American Standard
B18d—1930	Track Bolts and Nuts	American Standard
C1—1931	1931 Edition of the National Electrical Code	American Standard
C18—1930	Specifications for Dry Cells and Batteries	American Standard
C29a—1930	Standard Insulator Tests and Ratings	American Standard
G8b1—1931	Specifications for Zinc-Coated (Galvanized) Sheets	Amer. Tent. Std.
G8c—1930	Zinc Coatings on Structural Steel Shapes, Plates and Bars and Their Products	Amer. Tent. Std.
G12—1931	Specifications for Refined Wrought Iron Bars	Amer. Tent. Std.
G13—1931	Specifications for Wrought Iron Plates	Amer. Tent. Std.
K15—1930	Methods of Routine Analysis of White Pigments	American Standard
K18—1930	Method of Laboratory Sampling and Analysis of Coal and Coke	American Standard
L3—1931	Cotton Rubber-Lined Fire Hose	Amer. Tent. Std.
L5—1931	General Methods of Testing Woven Textile Fabrics	American Standard
M15—1931	Safety Code for Coal Mine Transportation	Amer. Rec. Practice
M17—1930	Fire Fighting Equipment in Metal Mines	Amer. Rec. Practice
O5a—1930	Ultimate Fiber Stresses of Wood Poles	American Standard
O5b1—1931	Specifications for Northern White Cedar Poles	Amer. Tent. Std.
O5b2—1931	Dimensions of Northern White Cedar Poles	American Standard
O5c1—1931	Specifications for Western Red Cedar Poles	Amer. Tent. Std.
O5c2—1931	Dimensions of Western Red Cedar Poles	American Standard
O5d1—1931	Specifications for Chestnut Poles	Amer. Tent. Std.
O5d2—1931	Dimensions of Chestnut Poles	American Standard
O5e1—1931	Specifications for Southern Pine Poles	Amer. Tent. Std.
O5e2—1931	Dimensions of Southern Pine Poles	American Standard
Z10c—1931	Symbols for Heat and Thermodynamics	Amer. Tent. Std.
Z11b—1930	Method of Test for Viscosity of Petroleum Products and Lubricants	American Standard
Z11e—1930	Method of Test for Cloud and Pour Points of Petroleum Products	Amer. Tent. Std.
Z11h—1930	Method of Test for Water and Sediment in Petroleum Products by Means of Centrifuge	American Standard
Z11i—1930	Method of Test for Water in Petroleum Products and Other Bituminous Materials	American Standard
Z11j—1930	Method of Test for Distillation of Gasoline Naphtha, Kerosene and similar Petroleum Products	American Standard
Z11k—1930	Method of Test for Distillation of Natural Gas Gasoline	American Standard
Z11q—1930	Method of Test for Burning Quality of Kerosene Oils	American Standard
Z11r—1930	Method of Test for Burning Quality of Mineral Seal Oil	American Standard
Z11s—1930	Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use	American Standard
Z11u—1930	Method of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline	American Standard Amer. Tent. Std.
Z11v—1930	Method of Test for Melting Point of Petrolatum	
Z11w—1930	Method of Test for Determination of Autogenous Ignition Temperatures	American Standard
Z12a—1930	Safety Code for Installation of Pulverized Fuel Systems	Amer. Tent. Std.
Z12f—1930	Safety Code for the Prevention of Dust Explosions in Coal Pneumatic Cleaning Plants	American Standard
Z22—1930	Motion Picture Standards	American Standard

Appendix C

AMERICAN STANDARDS ASSOCIATION TECHNICAL PROJECTS ON WHICH THE RAILWAY ASSOCIATIONS ARE NOW CO-OPERATING

	A.S.A. Project	*A.R.A. Div. or Sec. Represented A.R.E.A. (Const. & Maint. Sec.) Committee Contact*	*Members representing Railway Associations*
A1—1931	Portland Cement, Specifications for	IV Eng.—Com. VIII—Masonry	Meyer Hirschthal J. F. Leonard J. J. Yates
A21	Cast Iron Pipe and Special Castings, Specifications for	IV Eng.—Com. XIII — Water Service and Sanitation	C. R. Knowles Alt.—C. P. Van Gundy
A22	Walkway Surfaces, Safety Code for	IV Eng.—Com. VI—Buildings	W. T. Dorrance
A35	Manhole Frames and Covers	IV Eng.—Com. XIV — Yards and Terminals —Com. VI—Buildings I Oper.—T. & T. Sec.	H. L. Ripley Alt.—J. R. W. Ambrose Alt.—W. T. Dorrance R. F. Finley
A36	Rating of Rivers, Methods of	IV Eng.—Elec. Sec.	R. J. Needham
B1	Screw Threads, Standardization and Unification of	IV Eng.—Com. V—Track —Sig. Sec. V Mech.	J. V. Neubert H. G. Morgan H. E. Smith
B16	Pipe Flanges and Fittings	IV Eng.—Com. XIII — Water Service and Sanitation —Elec. Sec. V Mech.	C. R. Knowles J. V. B. Duer E. K. Post W. I. Cantley B. P. Flory
B18	Bolt, Nut and Rivet Proportions	A.R.A.—Rail Com. IV Eng.—Com. V—Track —Com. XV—Iron and Steel Structures V Mech.	E. E. Adams J. V. Neubert Alt.—J. B. Myers P. G. Lang, Jr. Alt.—O. E. Selby J. McMullen, C. B. Smith
B20	Conveyors and Conveying Machinery, Safety Code for	IV—Eng.—Com. XXIII — Shops and Locomotive Terminals	Vacant
B27P	Plain and Lock Washers	V Mech. VI Purchases and Stores	A. H. Fetters H. A. Hoke E. D. Toye Alt.—A. G. Follette
B30	Cranes, Derricks and Hoists, Safety Code for	IV Eng.—Com. XII—Rules and Organization	W. C. Barrett Alt.—M. M. Backus
B32P	Wire and Sheet Metal Gages	IV Eng.—Sig. Sec.	H. G. Morgan
B33P	Screw Threads for Hose Couplings (Other Than Fire Hose Couplings)	IV Eng.—Com. XIII — Water Service and Sanitation	W. L. Curtiss Alt.—J. P. Hanley
B36	Dimensions and Material of Wrought Iron and Wrought Steel Pipe and Tubing, Standardization of	IV Eng.—Com. XIII — Water Service and Sanitation V Mech.	J. J. Laudig Alt.—W. B. Nissly F. M. Waring
B40P	Pressure and Vacuum Gages, Specifications for	V Mech.	F. M. Waring
B41P	Stock Sizes, Shapes and Lengths for Iron and Steel Bars, Including Flats, Squares, Rounds and Other Shapes	V Mech.	H. G. Burnham
B42P	Leather Belting, Specifications for	VI Purchases and Stores	C. L. McIlvaine
B43P	Machine Pins, Dimensions of	V Mech.	A. H. Fetters H. A. Hoke
C1—1931	Electric Wiring and Apparatus in Relation to Fire Hazard, Regulations for (National Electrical Code)	IV Eng.—Elec. Sec.	G. O. Moores Alt.—I. V. Goodman

	A.S.A. Project	A.R.A. Div. or Sec. Represented A.R.E.A. (Const. & Maint. Sec.) Committee Contact	Members representing Railway Associations
C2—1927	National Electrical Safety Code	IV Eng.—Elec. Sec.	J. V. B. Duer H. M. Warren Alt.—L. S. Wells
		—Sig. Sec.	A. H. Rice G. H. Dryden Alt.—J. B. Lamb
		I Oper.—T. & T. Sec.	W. L. Morse R. F. Finley J. Miller
C5—1929	Lightning, Code for Protection Against	I Oper.—T. & T. Sec.	J. L. Niesse
C8	Wires and Cables, Insulated (Other Than Telephone and Telegraph), Specifications for	IV Eng.—Elec. Sec.	L. S. Wells Alt.—C. B. Martin
		—Sig. Sec.	W. H. Elliott
C10—1924	Electrical Equipment of Buildings, Symbols for	IV Eng.—Elec. Sec.	Vacant
C11—1927	Hard Drawn Aluminum Conductors	IV Eng.—Com. X—Signals and Interlocking	W. H. Elliott
		—Elec. Sec.	F. D. Hall
C16	Radio	I Oper.—T. & T. Sec.	J. J. Graf
C18—1930	Dry Cells and Batteries, Specifications for	I Oper.—T. & T. Sec. IV Eng.—Sig. Sec.	G. R. Stewart A. B. Himes
C29P	Insulators for Electric Power Lines	IV Eng.—Sig. Sec.	G. W. Chappell G. I. Wright
C34	Mercury Arc Rectifiers	IV Eng.—Elec. Sec.	G. I. Wright
C35	Railway Motors	IV Eng.—Com. XVIII—Electricity —Elec. Sec.	H. A. Currie J. E. Sharpley
C42	Electrical Terms, Definitions of	IV Eng.—Elec. Sec.	J. H. Davis
C44	Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases, Specifications for	IV Eng.—Sig. Sec. V Mech.	H. G. Morgan H. A. Currie
C50	Rotating Electrical Machinery	IV Eng.—Elec. Sec.	J. V. B. Duer
C52	Electric Welding Apparatus	IV Eng.—Constr. and Maint. Sec.	Lem Adams
D5	Street Traffic Signs, Signals and Markings, Manual on	IV Eng.—Sig. Sec.	A. H. Rudd
E8—1926	Seven-Inch, 82 Lb. Plain Girder Rail and Splice Bar for Use in Paved Streets, Design for	IV Eng.—Com. IV Rail and V Track	J. V. Neubert J. B. Strong
E9—1926	Seven-Inch, 92-Lb. Plain Girder Rail and Splice Bars for Use in Paved Streets, Design for	IV Eng.—Com. IV Rail and V Track	J. V. Neubert J. B. Strong
E10—1929	Special Track Work Materials, Specifications for	IV Eng.—Com. IV Rail and V Track	J. V. Neubert J. B. Strong
E11—1926	Seven-Inch, 102 Lb. Plain Girder Rail and Splice Bars for Use in Paved Streets, Design for	IV Eng.—Com. IV Rail and V Track	J. V. Neubert J. B. Strong
G8	Zinc Coating of Iron and Steel, Specifications for	IV Eng.—Com. I—Roadway	W. C. Swartout Alt.—C. P. Van Gundy
		I Oper.—T. & T. Sec.	R. F. Finley
M7A	Recommended Practices for Coal Mine Tracks, Signals and Switches	IV Eng.—Com. V—Track	C. J. Geyer
O3—1926	Cross Ties and Switch Ties, Specifications for	IV Eng.—Com. III—Ties	John Foley
O4	Wood, Method of Testing	IV Eng.—Com. VI—Buildings	W. T. Dorrance Alt.—J. W. Orrock

	A.S.A. Project	*A.R.A. Div. or Sec. Represented A.R.E.A. (Const. & Maint. Sec.) Committee Contact*	*Members representing Railway Associations*
O5	Wood Poles, Specifications for	I Oper.—T. & T. Sec.	R. F. Finley Alt.—H. A. Shepard
		IV Eng.—Elec. Sec.	P. Lebenbaum
Z2	Protection of the Heads and Eyes of Industrial Workers, National Safety Code for the	I Oper.—Medical and Surgical Sec.	A. E. Chace
Z4	Industrial Sanitation, Safety Code for	I Oper.—Medical and Surgical Sec.	Dr. G. G. Dowdall
Z10	Scientific and Engineering Symbols and Abbreviations	IV Eng.—Sig. Sec. —Const. & Maint. Sec.	E. K. Post Alt.—J. V. B. Duer M. R. Greenamyer H. M. Stout
Z14	Drawings and Drafting Room Practice (Exclusive of Architectural Drawings) Standards for	IV Eng.—Com. XI—Records and Accounts	G. R. Walsh
Z15	Graphic Presentation, Standards for	IV Eng.—Com. XI—Records and Accounts	G. R. Walsh
		—Sig. Sec.	H. G. Morgan
		I Oper.—T. & T. Sec.	C. E. Baxter
Z16	Standardization of Methods of Recording and Compiling Accident Statistics	I Oper.—Safety Sec.	T. H. Carrow

Note.—Other men serving on "Sub-Committees" of Sectional Committees of the A.S.A. selected by the Sectional Committees themselves, from outside of their own personnel, are not listed.

REPORT OF SPECIAL COMMITTEE ON MAINTENANCE OF WAY WORK EQUIPMENT

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G. R. WESTCOTT, *Vice-Chairman;*
O. L. BEYDLER,
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WILLIAM ELMER,
ROBERT FARIES,
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H. W. STETSON,
F. M. THOMSON,
N. M. TRAPNELL,
J. B. TRENHOLM,
FRED ZAVATKAY,

Committee.

To the American Railway Engineering Association:

Your Committee presents herewith report on the following subjects:

(2) Standardization of parts and accessories for railway maintenance motor cars (Appendix A).

It is recommended that the report be adopted for publication in the Manual as recommended practice and the subject continued.

(3) Adaptability of air and electric driven tools in railway and maintenance of way work (Appendix B).

It is recommended that the report be received as information and the subject continued.

(5) Use and adaptability of drag line equipment with caterpillar traction in maintenance of way work (Appendix C).

It is recommended that the report be received as information and the subject discontinued.

(8) The use and maintenance of paint spraying equipment with outline of typical organizations for various classes of work (Appendix D).

It is recommended that the report be received as information and the subject discontinued.

(10) Organization for the use and maintenance of ballast cleaning machines and conditions under which each particular type may be used, including moles, screens, locomotive cranes and plows used in conjunction with ballast discers (Appendix E).

It is recommended that the report be received as information and the subject discontinued.

(12) The use of oil spraying machines for oiling rails and fastenings, steel structures and roadbed (Appendix F).

Bulletin 341, November, 1931.

It is recommended this report be received as information and the subject discontinued.

Progress is reported on the following subjects:

(1) Definition of terms and preparation of material for Manual.

(4) Types of snow-melting devices as an aid in facilitating train operation and reducing maintenance cost.

(6) Methods of keeping data on work equipment and labor-saving devices.

(7) The selection and training of maintainers and operators of work equipment.

(9) Organization for the use and maintenance of tie-tamping machines, air and electric.

(11) Use of weed mowing equipment, including horse-drawn and power mowers operating both on and off the track.

(13) Prepare manual of instructions for care and operation of maintenance of way work equipment.

Respectfully submitted,

Special Committee on
Maintenance of Way Work Equipment,
C. R. Knowles, *Chairman.*

Appendix A

(2) STANDARDIZATION OF PARTS AND ACCESSORIES FOR RAILWAY MAINTENANCE MOTOR CARS

G. R. Westcott, Chairman, Sub-Committee; O. L. Beydler, Walter Constance, Paul Hamilton, R. C. Haynes, H. B. Hoyt, G. W. Hunt, Jack Largent, S. L. Mapes, E. H. Ness, C. H. Ordas, J. G. Sheldrick, Harry Slabotsky, H. W. Stetson, J. B. Trenholm, Fred Zavatkay.

This subject has been before the Association for several years, first under Committee XXII—Economics of Railway Labor, and later under the Special Committee on Maintenance of Way Work Equipment. For the last two years, recommendations for standard practices have been presented to the Association and adopted. These covered designs for wheels, axles, couplers, safety rails and tool trays.

During this year, your Committee has considered such details as sizes and types of frame bolts, types of gasoline lines, design of windshields, use of rail skids and extension lifting handles. The study has included the practices on a number of railways, and, as well, the recommendations of motor car manufacturers.

Your Committee also reports progress on design of gas tanks, brake shoes and ignition systems.

It should be borne in mind that the recommendations in this report, as was the case with recommendations previously adopted, apply only to cars used in maintenance gang service, particularly section duty cars.

The following is offered as recommended practice:

1. Frame bolts for Section Duty Motor Cars shall be ¼ in., ⅜ in., ½ in. and ⅝ in. in diameter and shall have U.S. standard cut threads. Carriage bolts in wood frames shall be equipped with head locks and lock nuts; machine bolts in steel frames shall be equipped with lock washers.

2. Gasoline lines shall be annealed copper tubing of not less than No. 19 B.W. gage in thickness, having ¼ in. outside diameter. Gasoline line connections shall be of packing type (see Fig. 1) with ⅛ in. pipe thread on one end and ½ in. S.A.E. standard No. 20 thread on the other end.

3. Cars shall be equipped with rail skids, the bottom of skid being not more than 3 in. above top of rail, skid being not more than ½ in. from back of wheel flange.

4. Extension lifting handles shall be provided at purchaser's option. If used, extension lifting handles should be of 1¼ in. pipe, preferably double strength, and provide 30 in. extension.

5. Windshields shall be of a type adaptable to the standard safety rails and shall be detachable. At purchaser's option, they shall have one or two windows of shatterproof glass or of viscoloid, or may be of baffle type.

In addition, your Committee offers as information, sketches as follows:

Fig. 2. Typical design for windshield.
Fig. 3 and 4. Typical designs for coupler drawbars.

Conclusions

1. That the above specifications 1 to 5 inclusive, be adopted as recommended practice and printed in the Manual.

2. That Fig. 1, 2, 3 and 4 be received as information.

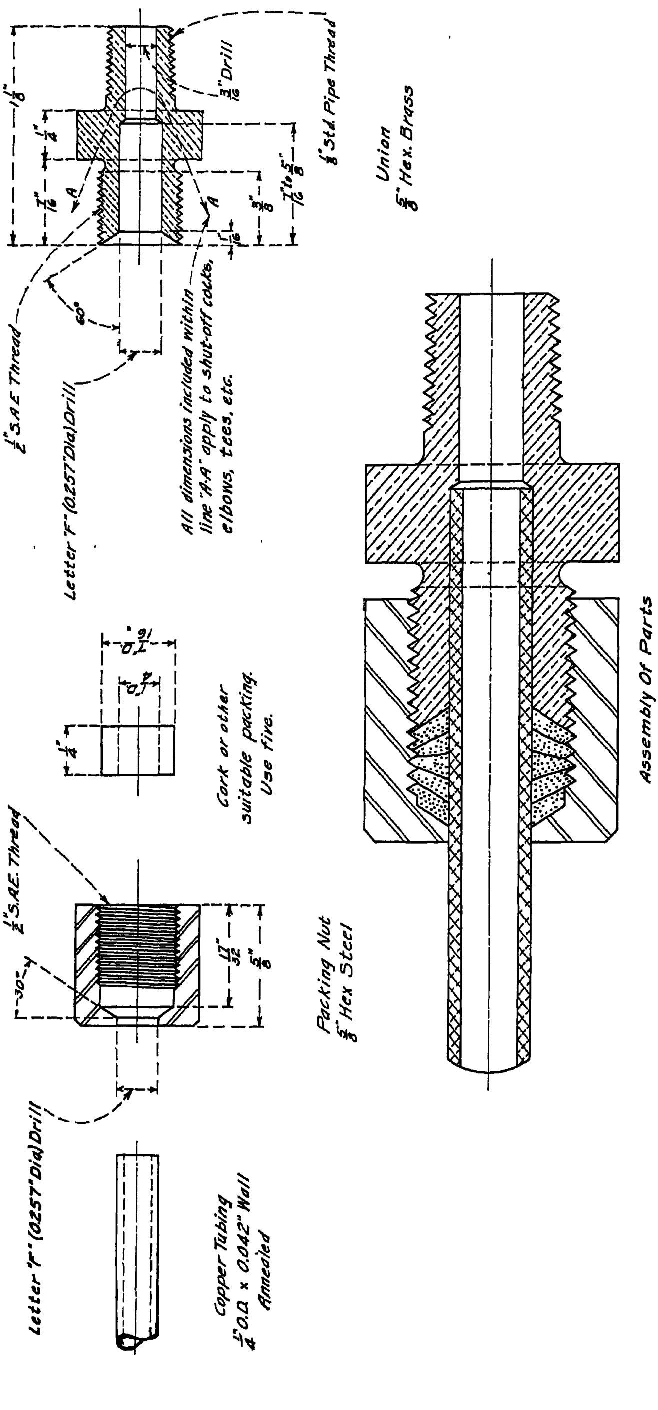

Fig. 1—Gasoline Line Connections.

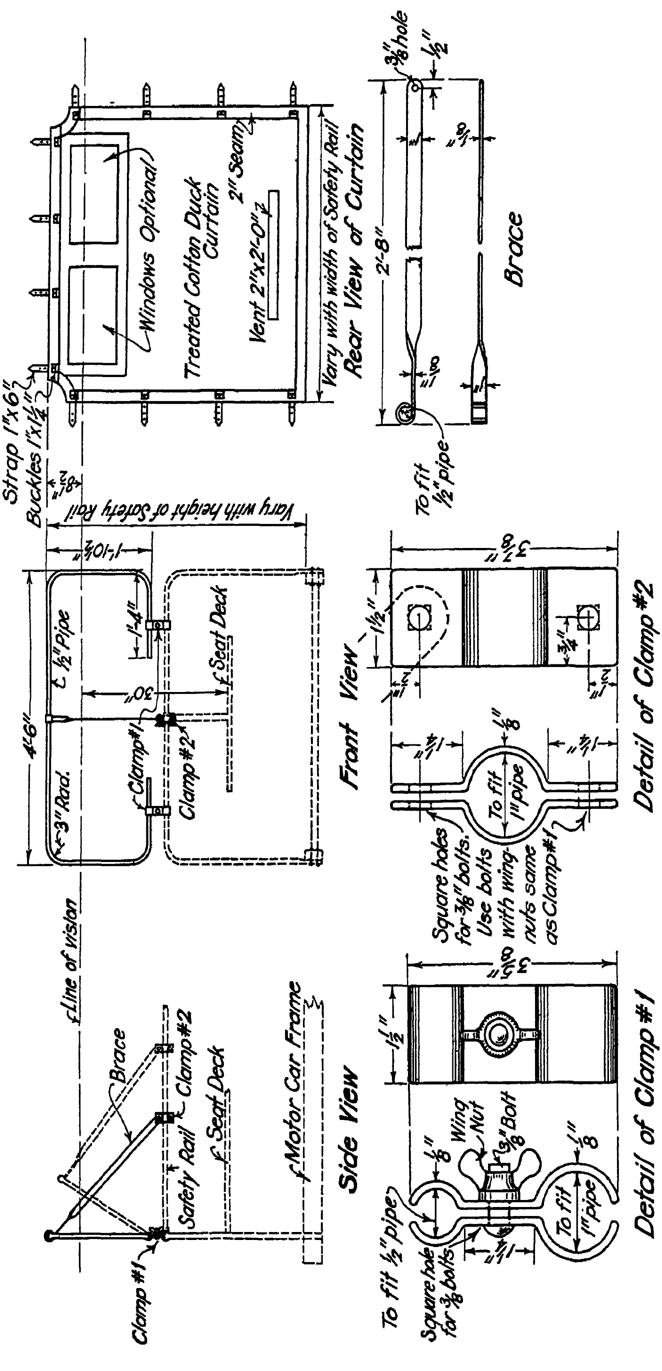

FIG. 2—TYPICAL DESIGN FOR WINDSHIELDS.

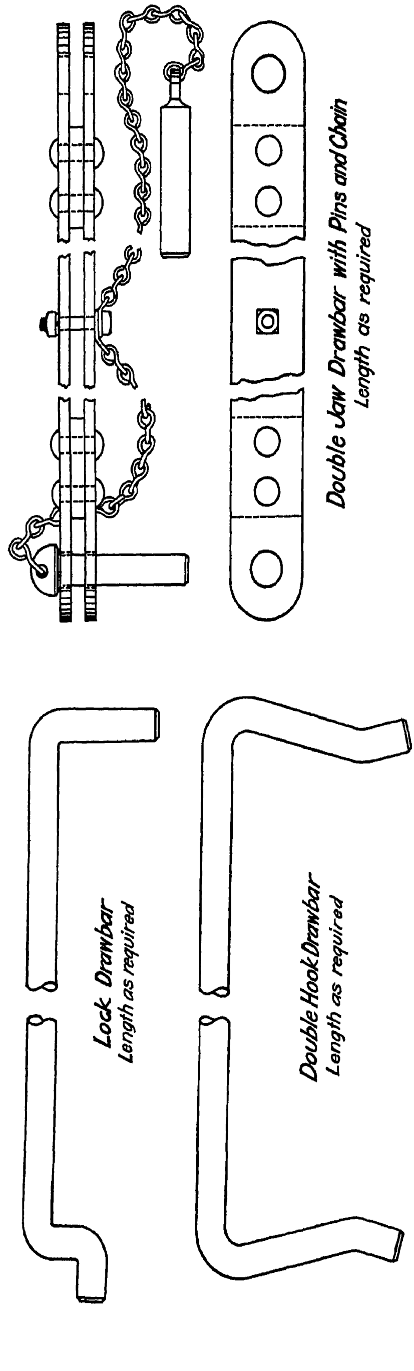

FIG. 3—TYPICAL DESIGN FOR COUPLER DRAWBAR.

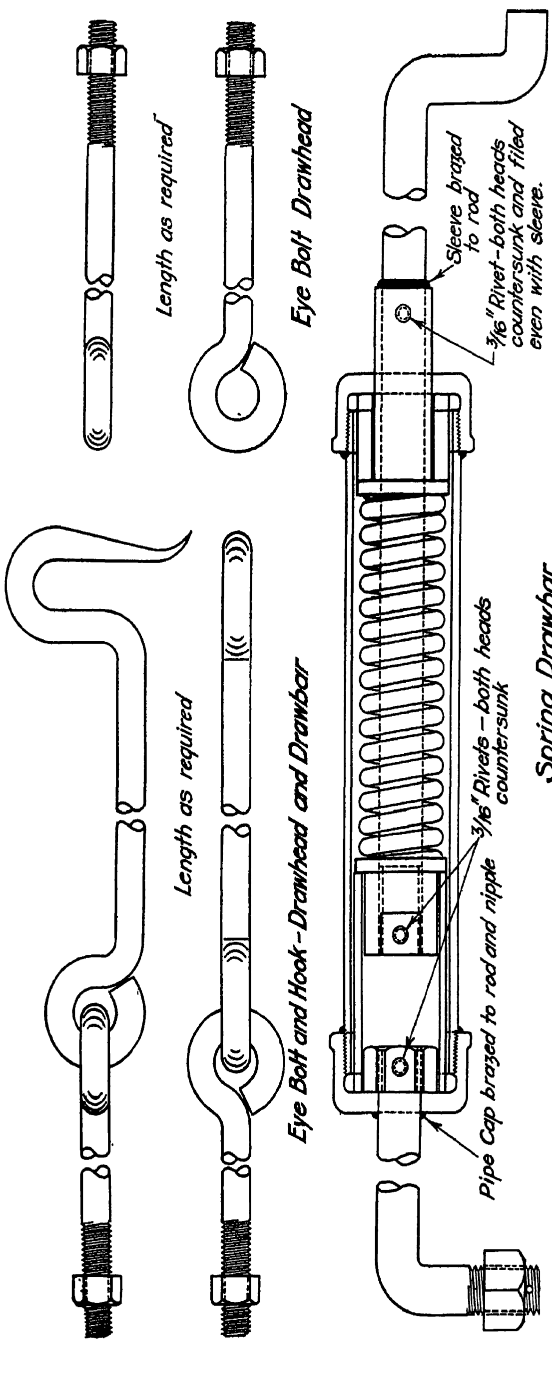

FIG. 4—TYPICAL DESIGN FOR COUPLER DRAWBAR.

Appendix B

(3) ADAPTABILITY OF AIR AND ELECTRIC DRIVEN TOOLS IN RAILWAY AND MAINTENANCE OF WAY WORK

J. S. Huntoon, Chairman, Sub-Committee; J. A. Cochran, J. F. Donovan, William Elmer, C. L. Fero, W. R. Golson, F. S. Hewes, F. W. Hillman, R. H. Kugler, C. H. Morse, S. H. Osborne, C. H. Paris, H. W. Stetson, N. M. Trapnell.

The adaptability of air and electric driven tools to railway maintenance of way work depends on the class of work and source of power.

This report does not take into consideration self-contained tools.

Serious consideration should be given to that class of power which will not interfere with railway traffic, or which will give a minimum possible delay to traffic.

The pneumatic rivet hammer and drill was first used about 1895 and since that time, compressed air as a source of power for small tools has had a rapid development in railway maintenance of way work. The pneumatic tie tampers were first used in 1913.

Modern pile drivers and derricks are equipped with air compressors. Where such equipment can be placed on a spur track, it affords a convenient source of power for operation of small tools. The portable air compressor with flange wheels is easily removed from the track and has proved efficient in track and bridge work. The earlier type of compressor for operating tie tampers was not designed for heavy duty bridge work and, when used for that purpose, the results proved unsatisfactory.

Some of the larger steel bridges are permanently piped so that air tools may be used for steel repairs, cleaning and painting the structure.

Small tools operated by electric power are of rather recent origin. Their use was confined to stations and cities where power could be obtained from power lines. Since the introduction of the portable generator, the number of electric driven tools has increased and made possible their use in bridge and building work, at locations where power lines have not been constructed. Recent developments in signal operation and train control have made it necessary to construct power lines along the right-of-way.

On certain railroads, connections can be made at various points along these power lines for operation of electric tools.

Some electrified terminals are designed so that electric motors can be attached for drilling rail and operating other small tools.

Compressed air and electricity were introduced in railroad work as an economic necessity for increasing the output per man. All railroads are operating at present under the necessity of reduced forces. The use of air and electric tools should assist in producing results that will help the present forces make up for reduced man power.

The output of work per person in the United States is higher than in any other country in the world due to the use of various forms of power. Small tools operated by air and electricity in railroad work have contributed their share to the efficient results. The following table was developed about 1923 by T. T. Read, Statistician. This table shows the output per man in various countries:

China	1.0	Australia	8.5
British India	1.25	Czecho-Slovakia	9.5
Russia	2.5	Germany	12.0
Italy	2.75	Belgium	16.0
Japan	3.5	Great Britain	18.0
Poland	6.0	Canada	20.0
Holland	7.0	United States	30.0
France	8.25		

APPLICATION OF COMPRESSED AIR THAT CAN BE USED FOR OPERATING SMALL TOOLS IN RAILWAY MAINTENANCE OF WAY WORK

1. Air hoists.
2. Applying and removing nuts from track bolts.
3. Backfilling trenches with air tampers.
4. Breaking concrete by drilling hole in concrete mass and using an air-expanding cartridge.
5. Caulking lead joints on water or gas mains.
6. Chipping and drilling holes in concrete.
7. Cleaning out concrete forms before pouring concrete.
8. Cut and screw spike pullers.
9. Drilling holes in steel and wood, also reamers.
10. Drilling holes under water, dock work.
11. Driving wood or steel sheet piling.
12. Operating pneumatic clay spades.
13. Operating scaling hammers for cleaning steel work.
14. Operating spray paint machines.
15. Operating trench pumps.
16. Operation of portable crosscut saws by bridge gangs.
17. Operation of rivet hammers, rivet busters, air buckers, and chipping hammers.
18. Operation of tie tampers.
19. Paving brakers.
20. Placing concrete in forms, such as tunnel lining.
21. Pneumatic one-man saws.
22. Pneumatic screw and cut-spike drivers.
23. Portable grinding machines.
24. Portable grinder with wire brush and other tools for facing concrete.
25. Portable pneumatic hoisting machines.
26. Rail loaders.
27. Sand blast.
28. Spray painting steel bridges and buildings.
29. Spraying structures with cement coating.
30. Vibrators for settling concrete in forms to give a more compact mass.
31. White-washing wing fences.

APPLICATION OF ELECTRICITY THAT CAN BE USED FOR OPERATION OF SMALL TOOLS IN RAILWAY MAINTENANCE WORK

1. Applying and removing nuts on track bolts.
2. Chipping hammers.
3. Crosscut saws for bridge gangs.
4. Cutting structural steel.
5. Drills for steel and wood.
6. Grinders for removing marks from concrete.
7. Grinding machines.
8. Portable one-man saws and planers.
9. Repairing in place by welding manganese and open-hearth crossings, frogs, rails and fastenings.
10. Repairing and strengthening metal structures by welding additional materials.
11. Tie scorer.
12. Tie tampers.
13. Vibrators for settling concrete in forms, to give a more compact mass.

Table I—Actual Use of Pneumatic Tools and Compressed Air on Various Railroads

Kind of Tool or Use of Compressed Air	*Railroad*								
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Rivet hammers	x	x	x	x	x	x	x	—	—
Chipping hammers	x	x	x	x	x	x	x	—	—
Drills for steel and timber	x	x	x	x	x	—	x	—	—
Power saws for wood and steel	x	x	x	x	—	—	—	—	—
Portable grinding machines	x	—	x	x	—	—	—	—	—
Cleaning out concrete forms	x	—	—	x	—	—	—	—	—
White-washing wing fences	—	x	—	x	—	—	—	—	—
Placing concrete in forms for tunnel lining	—	—	—	x	—	—	—	—	—
Spray paint machines	x	—	—	x	x	x	—	—	x
Tie tampers	x	—	—	x	x	x	x	—	—
Breaking concrete by drilling hole in concrete mass and using air expanding cartridge	—	—	—	x	—	—	—	—	—
Driving track spikes	x	—	—	x	—	—	—	—	—
Removing nuts from track bolts	x	—	x	x	—	—	x	x	—
Drilling holes under water—dock work	—	—	—	x	—	—	—	—	—
Pile drivers equipped with compressed air, other than air brakes	—	x	—	x	x	—	—	—	—
Portable air compressors with flange wheels	x	x	x	x	x	x	x	—	—
Portable air compressors with road wheels	x	—	—	—	—	—	—	—	—
Portable air compressor mounted on tractors	x	—	—	—	—	—	—	—	—
Large steel bridges permanently piped with air	—	x	x	—	—	—	—	—	—
Portable air compressor for painting interior and exterior of buildings	x	x	—	x	x	x	x	—	x
Cement guns	—	—	—	—	—	—	x	—	—
Spike driver and pullers	—	—	—	—	—	—	x	x	—
Rock drills	—	—	—	x	—	—	—	x	—
Paving breakers	—	—	—	—	—	—	—	x	—
Portable utility hoists	—	—	—	—	—	—	—	x	—

x denotes use of air tool or facility by designated road.

Table II—Actual Use of Electric Tools and Facilities on Various Railroads

Kind of Tool or Facility	*Railroad*								
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9
Portable power saws and planers for carpenter work	x	x	x	x	x	—	x	—	x
Cross-cut saws for bridge gangs	x	x	x	x	—	x	x	—	—
Motors with drills for steel and wood	x	x	x	—	x	—	x	—	x
Grinding machines	x	x	x	—	—	—	—	—	—
Repairing and strengthening metal structures by welding additional material	x	—	x	—	—	—	—	—	—
Welding crossing frogs in place	x	—	x	x	—	—	—	—	x
Electric tie tampers	x	x	x	x	—	x	x	—	—
Electric power lines along right-of-way for operating signals	x	x	x	—	—	—	—	—	—
Connection to power line for operating portable tools	x	—	—	—	—	—	—	—	—
Note—Road No. 1 does not permit connection to be made to signal power line, but has a special power line five miles long for experimental purposes.									

x denotes use of electric tool or facility by designated road.

The data on the use of electricity and compressed air for operating small tools was obtained from a questionnaire sent to various roads. The extent to which such tools are used is shown in the Tables I and II. By comparing the list of possible uses of such tools with Tables I and II it would appear that the use of air and electric tools could be further developed. Possibility of extended use of such tools depends somewhat on the class of men and the attitude of the supervising officer.

There is considerable difference of opinion regarding the relative merits and efficiency of air and electric tools. Tools with each class of power have their merits. Before deciding the proper tools, consideration must be given to available source of power, equipment on hand, results, and a source of power that will not interfere with or will cause the least interruption to railroad traffic.

One road reports that electric plants are more portable than pneumatic compressors and cost of operation is less. Electric plants are also considered more efficient as pipe lines quite frequently have air leaks at the joints.

Some of the air compressors are equipped with automatic hydraulic lifting arrangement which permits of ease in removing from track.

Various devices are used to prevent air lines from freezing in cold weather. Moisture traps are installed at air receivers. Alcohol is often injected into the air line by lubricator. An efficient device to prevent air lines from freezing by means of alcohol tanks was described in the 1930 Proceedings of the American Railway Bridge and Building Association, page 110.

Several roads report power lines constructed along the right-of-way. Only one road (not shown in Table II) permits connections to be made for operating electric tools. An eastern railroad has a power line 5 miles long, along the main line. This line is used as an experiment. It carries 2300 volts, 25 cycle, single phase current. The cost was several thousand dollars per mile. Transformers are installed so that a connection can be made every other pole, for operating electric tie tampers and other tools such as saws, drills and wrenches. The power can also be used for building up battered rail ends by welding.

Where suitable highways parallel railroads with frequent train service, it may be a decided advantage to truck compressors and generators to the working point.

One road has air compressors mounted on caterpillar treads and finds such an arrangement convenient and economical, around the construction of large bridges.

Conclusions

Compressed air and electric tools have proved economical and efficient in many railroad operations and there are possibilities for further development.

The Committee recommends that the subject be continued.

Appendix C

(5) USE AND ADAPTABILITY OF DRAGLINE EQUIPMENT WITH CATERPILLAR TRACTION IN MAINTENANCE OF WAY WORK

T. M. Pittman, Jr., Chairman, Sub-Committee; J. A. Cochran, S. E. Coombs, J. F. Donovan, C. L. Fero, Paul Hamilton, C. H. R. Howe, J. S. Huntoon, R. H. Kugler, C. H. Morse, E. H. Ness, S. H. Osborne, C. H. Paris, Harry Slabotsky, H. W. Stetson.

General Description

Dragline machines mounted on caterpillar tractors driven by gasoline motors have been in general use by grading and drainage contractors for a number of years, but their use on railroad maintenance of way work is a recent development and even now a very few of the roads have availed themselves of the economies offered by this type of equipment. In general this type of equipment consists of an engine, similar to a hoisting engine, equipped with drums, gears, clutches, etc., and a boom to which a dragline bucket is attached. This plant is mounted on a frame carried on caterpillar tractor treads and may be operated by a gasoline or electric motor, or a Diesel or steam engine. Most manufacturers provide auxiliary equipment which is interchangeable so the machine can be equipped to operate a clamshell, shovel, hoisting derrick, pile driver or magnet. The cabs are enclosed which makes it possible to operate under all but the most severe weather conditions. The caterpillar treads distribute the load sufficiently to permit operation over ground too soft for teams and by the use of mats to further distribute the load operation in marshy ground is possible. Mats are made of old bridge stringers fastened together or by two layers of 5 in. x 10 in. planks. A loop of cable should be provided for easy handling. The size of the mats will be determined by the nature of the soil but under ordinary conditions mats 4 ft. wide by 14 ft. long will be sufficient. The mats may also be used as skids for unloading the machine from flat cars. The treads of the machine are run up on the mats and as soon as the machine has passed over one, it is picked up by the boom, which has a full circle swing, and placed in front of the treads. The crawler treads are usually about 12 ft. long so the machine can be kept moving with four 14 ft. mats.

Class of Work for Which Adapted

The dragline is suitable for almost any work involving the handling of dirt or material and is especially adapted to grading, ditching, widening banks, widening cuts, cleaning out under bridges, cleaning drift, cleaning out reservoirs, loading and unloading cinders or gravel, etc., and when equipped as a derrick or with a magnet or leads is convenient for loading or unloading rails, handling timbers in heavy building construction, handling structural steel in light bridge and building work, driving piling for foundations, wing walls, etc.; which a track driver cannot reach. One road reports its use on a rush job of constructing an industry spur track one-fourth of a mile long, first doing the grading, then handling and distributing ties and rail from the cars, unloading the gravel and finally lifting the track to its surface and line. Another road reports stripping a gravel pit and loading gravel in cars on the loading track, eliminating the use of a work train for spotting cars. In loading and unloading rail, the machine can move from one flat car to another under its own power thereby avoiding extra switching. In widening banks, cleaning out cuts, etc., it works in the clear of tracks and is not hindered by traffic. The machine can be loaded on a flat car ready for moving in less

than two hours and unloaded in about one-half hour, which greatly facilitates its transfer from one job to another.

Bridge stringers with supports of proper height can be carried with the outfit to provide an incline for loading and unloading or ties can be laid in crib form and the mats placed on them.

Some operators prefer to take the trucks from under one end of the flat car and let the floor of the car rest on the rails. The machine can then be run directly to the track without any blocking or cribbing. The machine will move on or off the car under its own power. In moving, the boom is usually allowed to rest on an idler car so that two flat cars will be required. The outfit ready for shipment weighs about 54,000 lb. which permits it to move the full length of a car without risk of damage to the car. The draglines are generally operated with a crew of two men, an operator and helper, whose rates of pay are about the same as the engineer and fireman of the American ditchers. These men should be assigned to the machine and move with it, being assigned to the territory covered by the machine, so the machine will not be manned by a green crew when moved to another division. These men should be selected with a view of their ability to make light repairs in the field as well as to operate the machine.

Method and Cost of Operation

Responses to questionnaires indicate very few of the roads are using this equipment in maintenance of way work. The accompanying statement shows the chief operating features of these machines for the various roads. It is significant that every road using them endorses them very highly and in most cases have extended their use in subsequent years; one large system now operates 20 machines. Much of the work done is not susceptible of accurate measurement and reliable cost data are not available. The figures given, however, seem to be well in line and it is felt that they represent very closely the results that may be expected.

The most popular type of machine is operated by gasoline motor and consumes from 20 to 30 gallons of gasoline per day of eight hours continuous operation depending upon the class of work. The daily cost of operation is about $15.00 per eight hour shift, during which time from 400 to 900 cubic yards of dirt can be moved depending upon the nature of the work, giving a cost per yard of from 4 cents to 10 cents. On one job of cutting a new channel involving approximately 12,000 cu. yd., the work was done for 3½ cents per cu. yd. which included expense of moving the machine to the job. The low operating expense makes it possible to keep the machine at work during period of restricted expenditures when it would be necessary to shut down other types of machines requiring train service. Reports indicate that the machines average working from 180 to 250 days per year which is significant as indicating the amount of work available and the ability to keep the machines at work. Very few machines were idle on account of lack of work.

Repairs and Depreciation

Information concerning depreciation is somewhat meager. The reports indicate that repairs run about 5 per cent to 8 per cent of the original cost except for one railway which shows 15 per cent. It is felt that a conservative estimate would be about 10 per cent and that at the end of ten years the amount spent on repairs would very nearly equal the original purchase price, but at the same time the machine should be in first-class condition. However, at the end of ten years it might be desired to replace the old machine with an improved type, therefore it is advisable to consider an annual depreciation charge of 10 per cent.

Desirable Features

The following suggestions are offered as an aid in the selection of a dragline:

Treads.—The caterpillar treads should be free cleaning and so spaced that they will not pinch or pick up the rails in crossing over the track. The gage of the treads should be such that the machine can be loaded on a flat car without excessive overhang at the sides, and if desired, can be wide enough to permit the machine to straddle the rails while driving down the track, running upon the ends of the cross-ties.

Engines.—The gasoline motor has the advantage of a more readily available fuel supply, more convenient facilities for repairing and less weight than the Diesel motor. The machine should be geared to two speeds, one for moving while working and the other fast speed for longer moves. The gears should be arranged so that either tread can be worked independently of the other, so one tread can move forward while the other moves backward enabling the machine to be turned around in its own length. The crank-case should be tightly sealed to prevent mud and grit getting into it from the bottom and the engine should be powerful enough to pull the machine up a slope of approximately three to one under its own power.

General.—The cab should be cut off on the back as much as possible to provide greater clearance and should be arranged so as to give the operator the greatest amount of room possible and provide ventilation. It should be fitted with windows and doors so the machine may be securely locked and left on the job overnight. If it is desired, electric lights may be installed to permit night-work. The dimensions of the machine loaded on a flat car should conform to the minimum clearances on the district on which it will move.

Conclusions

Dragline machines mounted on caterpillar treads, with interchangeable equipment, are useful and economical. Their uses are so varied that most roads will have sufficient necessity for them to justify their purchase.

Name of Road	Canadian Pacific	Pennsylvania	Erie	C. B. & Q.	Union Pacific System	Soo Line	Illinois Central System
No. of Machines in Service	4	17	1	16	20	1	3
(a) Kind of Power	Gasoline	Gasoline	Gasoline	Gas. 14 Steam 1 Gas. Elec. 1	Gasoline	Gasoline	Gasoline
Average Age—years	3	2	3	4 oldest 9	2.2	2	2
Ave. No. days worked per year	180	210c	215	200–250	179	253	252
(a) No. days lost for repairs	10	25	12	60	24	22	25
(b) No. days lost account no work	0	5	0	0	----	23	0
No. cu. yds. handled per day	----	----	900	700–1200	406	506	300–500
Cost per cu. yard	----	----	0.04 side casting	4–10c	5.5c	9.6c	3½ to 10c
Est. cost to do same work by contract	a	----	----	15–35c	----	12c	30c
Cost to operate per 8 hours	----	$14.00	$15.00	----	$22.52	$15.75—10 hours	$12.00
Gals. Fuel Consumed: 8 hrs.	20 Imp gals.	30 gals.	19.5	----	22	24	22
Cost of Maint. per Machine per year	----	1500	625	300–500	1050	1671i	450
Percentage of Annual Maint. to Orig. Cost	----	15	5	About 5%	8.6	13.3i	5%
Has Mach. proven practical and economical	Yes	Yes	Yes	Yes	Yes	Yes	Yes
For what different classes of work has it been used	b	d	e	f	g	h	j
What Other Attachments are used with mach.	----	Clam Shell Shovel Dipper	Clam Shell Shovel Dipper	Pile Driver Clam Shell Shovel Dpr.	Pile Driver Shell Dipper	Clam Shell Shovel Dipper	Clam Shell Shovel Dipper
Is Machine assigned to Division or System	System	Division	System	System	----	System	System
Do Oprts. stay with mach. on dif. divs.	----	Yes	Yes	Yes	Yes	Yes	Yes
No. Men assigned to Machine	1	1	2	2	2	2	2
Size of dipper	½ cu. yd. dirt or 2½ cu. yd. snow	¾ cu. yd.	¾ cu. yd. clam shell 1 cu. yd. D. L.	1 cu. yd. ¾ cu. yd.	1 cu. yd. ¾ cu. yd. 1¼ cu. yd.	1 cu. yd.	¾ cu. yd.
Rental charged on A & B work	----	15.00	----	9.00	0	9.00	0

[a] Estimated saving about $5000 but no details available account of work being too varied.

[b] Loading gravel, excavation for highway diversion, basements and pipe lines, ditching, handling rock and cinders, erecting steel work, loading snow, loading and unloading supplies.

[c] Only about 30 days as dragline, balance as clam shell, magnet, shovel, etc.

[d] Ditching, reducing slopes of embankments, cleaning out culverts and reservoirs, digging water channels, etc.

[e] Digging creeks, unloading cinders with clam shell, digging shoulder for new ballast, digging center track space, ditching, unloading rail, setting steel for new bridges, slope grading.

[f] Digging channels, bank widening, ballast loading, bridge excavation.

[g] Loading gravel, new embankment, restoring embankment, cleaning channels, excavating at bridges, excavating ditches, placing riprap.

[h] Loading cinders and gravel, fill bridges, dig ditches, grading for tracks, stripping gravel pits, cutting down banks, excavating under water.

[i] Cost of repairs high on account of accident.

[j] Widening banks and cuts, digging new channels, cleaning ditches, cleaning reservoirs, placing pipe under high fill, new embankment.

Appendix D

(8) THE USE AND MAINTENANCE OF PAINT SPRAYING EQUIPMENT WITH OUTLINE OF TYPICAL ORGANIZATIONS FOR VARIOUS CLASSES OF WORK

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The purpose of paint spraying equipment, as the name implies, is to deposit paint on a surface by projecting the paint against the surface in the form of a finely atomized spray.

The first patent covering a paint spraying machine was issued nearly sixty years ago, the original device being designed for the application of whitewash and similar forms of water-paint. As the machine was improved and adapted to handle other kinds of paints, its use became more extensive and today there is hardly a field requiring the use of paint in which it is not an important factor.

This is particularly true in the painting of automobiles, where the development of the spray method of painting has been largely responsible for the phenomenal output with which every one is familiar. If every automobile had to be brush painted, as was formerly done, the production would be limited by the time required for finishing. The same thing is true in the finishing of furniture.

It is only within the last few years, however, that paint spraying equipment has been adapted to railroad uses, and while progress has been slow in this field there is no doubt but what it is destined to supplant brush painting, except for a certain few classes of work, and even these may be taken care of by future developments. The principal reason for the development of paint spraying equipment is the great saving in time and labor cost effected by its use, as compared with hand brush painting.

The earlier paint spraying machines were very crude as compared to the modern spraying equipment, which bears but little resemblance to the earlier devices. Modern paint spraying equipment consists essentially of three main units, as follows:

(1) A paint container or reservoir.
(2) A source of power supply, usually an air pump or compressor.
(3) A nozzle or "gun" for atomizing and projecting the paint spray.

The three units are connected together by suitable pipes or flexible tubing. The atomization and projection of the paint spray is done by means of compressed air in practically every case.

Paint spraying machines are made in various types adapted for use on various classes of work, and each type is made in various sizes or capacities depending on the magnitude of the work. Thus, we have the portable type designed to be moved about from place to place, the stationary or fixed type as is used with spray-booths, in which the air compressor and paint containers are installed permanently in one location, and a third type, sometimes called the semi-portable type, in which the paint container is portable and the air supply designed to be taken from a connection to a permanent air line. All three types are made with paint containers having capacities of from one quart up to fifteen or twenty gallons.

Spraying machines may also be classified according to the method of feeding paint to the gun, as follows:

(a) Pressure feed, in which air pressure is applied to the paint in a closed container, forcing it through flexible tubing to the gun.
(b) Syphon feed, in which the paint container is attached directly to the gun and the paint drawn into the gun by the syphon action of an air jet in the nozzle.
(c) Gravity feed, in which the paint container is mounted or suspended above the gun and the paint flows by gravity, through flexible tubing to the gun.

In all types compressed air is piped directly to the gun by means of flexible tubing. Pressure feed is the most generally used in railroad work, as this type of equipment can be made in practically any capacity, more than one spray gun can be operated from a single paint container and guns can be operated at a considerable distance from the container, thus allowing considerable flexibility in the use of the equipment. The syphon feed is used on portable equipment of small capacity, and the gravity feed is used on portable or semi-portable equipment usually of from two to ten gallons capacity.

Paint spray guns are made in various types and sizes to suit different kinds of work. The most common type is the ordinary hand gun used where the work is readily accessible to the operator. The extension gun was developed for use where a long reach is required without extra scaffolding and is made in lengths of from four to ten feet. Each gun is equipped with connections for the air and paint supply hoses, and is provided with a trigger-operated valve for opening or shutting-off the paint supply.

The spray gun nozzle in which the paint is mixed with the air, atomized and projected in the form of a spray, is made in several designs for various classes of work. Thus some nozzles are designed to handle heavy thick paints, which are projected in a comparatively coarse spray for applying a heavy coat to the surface. Others are designed to handle thin paints which are projected in a fine spray for applying a light coat. Nozzles are usually equipped with some form of needle valve adjustment for controlling the amount of paint emitted and the form of the spray. This allows the use of a heavy spray of large diameter for covering surfaces of considerable extent and a light spray of small diameter for covering smaller surfaces. Many roads find it possible to use one size and type of nozzle for all classes of work. Some use two sizes, the larger designed to give a spray up to 16 inches wide for large outside surfaces and the smaller designed to give a fine spray for interior work.

The air pressure for atomizing the spray and for feeding the paint to the gun in the pressure-feed system, is controlled and regulated by suitable reducing valves, usually mounted on the cover of the paint container. The air pressure in the paint hose must be just sufficient to force an adequate supply of paint to the nozzle, and must be increased as the elevation of the spray gun above the container increases. A pressure of one pound per square inch per foot of elevation is considered suitable under average conditions with average paints. Lighter paints will, of course, require less pressure and heavier paints more.

The atomizing pressure used varies from fourteen to ninety pounds per square inch, the average being between fifty and seventy pounds per square inch. This pressure depends on the kind of paint, the type and size of nozzle, and on wind and weather conditions. In general, this pressure is increased as the viscosity of the paint or the velocity of the wind increases.

The size of the air compressor used with paint spraying equipment depends on the capacity of the equipment and on the method of cleaning the surfaces preparatory to painting. They range in size from very small machines for operating a single small

spray gun up to large machines of 160, or more, cubic feet per minute capacity for operating six or eight spray guns or several chipping hammers, wire cleaning brushes, sand blast machines, etc. The most common sizes of compressors used in railroad work lie between fifteen and thirty cubic feet of free air per minute capacity, operating two-gun outfits. However, steel bridge cleaning is as important as the painting, and the cleaning often requires compressors of larger capacity.

The source of power for driving the compressor is either a gasoline engine or an electric motor. The size of the engine or motor used depends, of course, on the capacity of the compressor. The gasoline engines used are built in sizes of from ¾ H.P. to 60 H.P. and the electric motors from ½ H.P. to 25 H.P. Most portable machines are gasoline engine driven, as the engine is a self-contained power unit and requires no connection to an external source of power. Most stationary, or permanent, paint spraying installations are driven by the electric motor as they are usually located where a source of electric power supply is readily available. Some small portable machines, particularly those used inside buildings, are electric driven and are so arranged that they can be readily connected to the ordinary lighting circuit. Either alternating or direct current motors may be used.

Portable paint spraying equipment is, of course, the type most widely used in railway maintenance work. Various methods of mounting and transporting the machines are adopted, depending on the size of the equipment and the conditions under which it is to be used. The air compressor, the engine or motor, and the air storage reservoir are usually mounted on a frame as a single power unit. The paint container is carried as a separate unit so that it may be placed at some distance from the power unit when necessary, and as near as possible to the spray gun, so as to keep the length of the paint feed hose between the container and the gun as short as possible.

The power unit may be mounted on skids, or on wheels in the form of a hand-truck, push car or motor car trailer. The type of mount showing the widest use is the ordinary flat rim three or four wheel hand truck. The advantage in this mount is that it can be moved about readily at the job and can be easily moved on or off push cars or box cars. Some roads use skid mounting for the larger power units and transport them in box cars or on push cars, but most of the larger units are mounted as motor car trailers equipped with facilities for jacking and skidding them sideways, clear of the track at the job. In some cases the power unit is mounted directly on a motor car and the motor car engine is arranged to drive the compressor, when set up at the job.

In at least one case, the power unit is mounted on wheels and set up in a box car from which the air is piped to the job. In some instances the work can be more conveniently reached by highway than by the railway. Under these conditions the equipment is usually transported by motor truck to the site of the work. Also, in at least one case the power unit is mounted on an auto-trailer.

As previously stated, paint spraying equipment is available for practically every class of work; however, in railway practice, there are many kinds of work which are still done by hand brush painting. The question of whether spray or brush painting is to be used is entirely one of economics. This question may be considered from two standpoints, i.e., the relative first cost of applying the paint and the relative annual cost; taking into account the cost of applying the paint, and the relative durability or life of the paint coat applied by the spray and by brush. The concensus of opinion seems to be that the first standpoint, that is, the relative cost of applying the paint, is the governing factor, as there seems to be very little difference in the durability of paint applied by spray and by brush.

The decision as to whether spray or brush painting is cheaper depends on the amount of work ahead and the nature of the jobs. That is, in order to justify spray painting, the job must be big enough to stand the cost of moving, unloading and setting up the equipment, as well as the cost of operation, including labor, fuel, lubricants, maintenance, etc.; also interest and depreciation on the capital investment in equipment. It should be borne in mind that practically every paint gang must be equipped to handle a certain amount of brush painting even though provided with spraying machines.

In general, large unbroken areas, such as girder bridges, warehouses, water tanks, turntables, coaling stations and large station buildings are painted most economically by the spray, while small isolated structures, such as small truss bridges, small buildings and those requiring considerable trim, are often most economically painted by brush. It seems to be the consensus of opinion that most maintenance of way painting can be handled economically by the spray, but that certain special classes of work are done most economically by brush, as follows:

(1) Most interior decorating and painting, except shops and engine houses.
(2) Some spot painting where ballasted-deck bridges are leaking and appearance is of minor importance. Also light steel structures such as overhead catenary construction and steel structures in the vicinity of high-tension wires.
(3) Bridges located where the vehicle and pedestrian traffic is so dense that the danger of property damage makes spray painting impractical.
(4) Fences with large openings between the pickets.
(5) Buildings where two or more colors must be applied.
(6) Small jobs in isolated locations.

The final decision as to the method of painting used on any particular job will rest largely with the foreman in charge or the supervisor; however, the laying down of a general basis for division of the work between spray and brush painting seems desirable both to guide the foreman in his decision and to allow proper programming of the work.

It also seems desirable to plan a program to provide maximum annual utilization of spraying equipment. There appears to be two general methods of attempting this. The first is by the use of large compressors which can be utilized for other work during the season when painting is not being done. The objections to this scheme are that paint spraying requires only a relatively small compressor and a larger machine tends toward inefficiency when used only for paint spraying, and that in the winter season, when painting is slack, other work is likely to be slack with a consequent oversupply of equipment. The second scheme calls for the painting of exterior work in the summer and the painting of interior work during the winter. This method has the disadvantage of requiring two trips over the division, or system, for the completion of the program, but it has an offsetting advantage in that skilled workmen are retained throughout the year, the gangs being merely increased somewhat for the summer work.

The cleaning and preparation of the surface to be painted is of great importance. This can usually be done most economically by mechanical tools, usually air driven. This fact has had considerable influence in tending to promote the use of paint spraying equipment on railroads, as, since air must usually be available for cleaning, it is logical to use paint spraying equipment operated from the same air supply. This is particularly true in the case of steel structures such as bridges, turntables, etc.

Metal surfaces are usually cleaned by means of chipping hammers, scaling tools, steel wire brushes or steel hook scrapers. Sand-blast is used in some cases on large jobs. The cleaning of wooden surfaces is usually done with blow torch and scrapers or with steel wire brushes. In both cases an air jet is usually used to blow the refuse from the surface before painting.

In general, there is very little difference in the method of mixing and preparing paints for use in paint spraying equipment and for hand brush painting, except that, in many cases, paint for use in spraying equipment must be mixed somewhat thinner and must be more carefully strained than for brushing. Many pressure containers are equipped with mechanical agitators in order to keep the paint properly mixed and of the proper consistency.

This is to aid in preventing the spraying equipment from becoming clogged. It is extremely important that guns, hose, and containers be kept clean. They should be thoroughly cleaned after each day's work or when changing colors. However, this is comparatively easy to do with machines of modern design, as the guns and containers are constructed so as to be readily taken apart, and special paint solvents are available for cleaning paint hoses.

Maintenance of way painting is usually handled either by the division forces or by permanent system paint gangs. The modern tendency, particularly on the larger systems, seems to be toward the use of system paint gangs. The chief advantage in this arrangement is, of course, economy, and the fact that it lends itself more readily to the adoption of a program of work which will provide practically continuous employment for skilled workmen throughout the year. It also eliminates the necessity for much duplication of equipment and allows the more intensive and economical use of efficient equipment, which would not otherwise be purchased, because of high cost. This has tended to promote the use of paint spraying equipment.

On some of the larger systems regular "paint trains" are operated. A typical consist of such a train is as follows:

1 Sleeping car.
1 Recreation car.
1 Kitchen and Dining car.
1 Paint car.
1 Machinery car with power paint mixers.
1 Storage car.

A typical force for manning a paint train is as follows:

1 Foreman.
1 Assistant Foreman.
1 Machine Operator.
5 Painters.
8 Painter Helpers.
1 Cook.
1 Camp Car Attendant.

The organization of the force for handling paint spraying equipment will depend on the size of the equipment, that is, the number of guns operated, capacity, etc. It will also depend, to some extent, on the kind of work being done. The force should include, in addition to the foreman, one machine operator to care for the air compressor and maintain the equipment, sufficient skilled painters to prepare paints and operate the guns, and sufficient helpers or laborers to move the equipment, set-up and take-down scaffolding, clean surfaces to be painted, etc. A typical organization for handling two 2-gun machines is as shown above for the paint train. A typical organization for handling a single 2-gun machine is as follows:

1 Foreman.
1 Machine operator for operating air compressor, handling pipe and hose lines, sharpening tools, making repairs, etc.
3 Men with air chippers and air brushes, who apply priming coat by hand when necessary.
1 Man with air-jet blowing off dust and dirt ahead of sprays.
2 Painters operating spray guns.

In some cases on large jobs, such as the painting of a large steel bridge, the cleaning and painting operations are divided, and the two gangs placed under separate foremen. A typical organization of this kind using sand-blast for cleaning is as follows:

CLEANING:
1 Foreman.
1 Machine operator for operating air compressor, making repairs, etc.
1 Sand blast nozzle operator.
2 Men working ahead of sand blast, cleaning off heavy scale, supplying sand to storage drum and erecting scaffolding.

PAINTING:
1 Foreman.
3 Painters, operating spray guns.

As can be seen from the foregoing, there is, at present, no hard and fast rule or standard practice governing the organization of forces for the handling of paint spray equipment, which is likely to be different on different railroads even though the equipment may be of the same type and the operating conditions practically the same. It is possible, however, that as further experience is gained in the handling of the equipment and as its use becomes more widespread, there will be developed certain standard practices in force organization for a given type of equipment on certain classes of work.

In general, very little difficulty has been encountered in training men to operate paint spraying equipment efficiently. In some cases, however, trouble has been experienced in getting experienced hand-painters to adopt the spray method. This seems to be due often to a fear of the harmful effect of paint fumes, and the difficulty is overcome by providing the men with nose-guards or respirators. There is very little real need for respirators on outside work, except possibly on large jobs. Respirators should be used, however, on inside work.

In regard to the relative appearance and durability of paint applied by spraying and by brushing, it seems to be the general consensus of opinion that spray painting is at least equal, if not superior, to brush painting in these respects. Many authorities are of the opinion that spray painting is considerably superior. The appearance and durability in either case depend to a great extent, of course, on the experience and skill of the operator.

Paint which has been sprayed onto a surface should retain its gloss longer than that applied by brushing. This is due to the fact that the former has a smooth even surface, while brushing leaves a rougher and somewhat rigid surface consisting of a series of minute grooves made by the bristles of the brush, which allow dust to collect more readily on the surface. Also, continued observations over the life of the paint will show that the thinner part of the film in the troughs of the grooves is always the first to perish. This grooving is always present to some extent in brush painting no matter how skilful the operator may be.

When the spray method is used, a skilled operator applies the paint in a finely and evenly atomized state, and is able to apply very thin layers of a uniform thickness which are free from blemishes. The rate of flow of the paint can be adjusted to meet varying requirements, so that he can cover the surface adequately with a minimum amount of paint. The finished surface is free from the grooving effect of the brush and, therefore, does not collect dust as readily as does a brushed surface.

One of the principal causes of paint failure is the oxidation of the paint film or vehicle in which the pigment is carried. Under ordinary conditions this process is a slow one and is generally called "weathering". Oxidation is accelerated, however, by the ac-

tion of sunlight, principally the ultra-violet rays, although it is likely that other actinic rays assist. The first and most direct result is a loss of elasticity which is followed by checking and scaling, and eventually a general failure of the entire paint film.

Wood fiber possesses the ability, varying with the species, of absorbing and holding moisture. When moisture is absorbed, the wood expands and when it dries out it contracts. Practically all standard paints are sufficiently elastic when first applied to permit these changes to take place without causing any damage to the paint film. As oxidation progresses and the elasticity diminishes, a point is reached where the paint film is unable to respond and it is literally sheared off the wood. At this stage the paint begins to crack and becomes practically useless for protective purposes. The same action occurs with paint on iron and steel structures, but in this case the expansion and contraction of the surface results from changes in the temperature of the metal. The effect on the paint is the same, however.

Moisture may cause similar failures in a different manner. In the north an accumulation of moisture near the surface of the wood is not unusual. If this accumulation remains at the approach of cold weather, the freezing of the water may cause as much scaling as results from other causes. Other sources of trouble are bleeding of saps or resins and the failure of the paint to adhere to knots.

These causes of the failure of the paint film have been mentioned because the method of application has a distinct bearing on the durability of the paint. No matter how skilful a painter may be he is unable to apply the paint with a uniform thickness by brushing because of the grooving action of the bristles, as explained previously. On the other hand, if the operator is equally skilful, the paint applied with the spray will have a more uniform thickness and oxidation will occur uniformly over the entire surface. The life of the paint, therefore, will practically be the same over the entire area and will not depend on the life at the thinnest places, so that it will be increased about in proportion to the uniformity with which the coat has been applied.

Furthermore, the density of the film of paint applied with the spray gun is somewhat greater than that applied with the brush so that, with the same material, the amount of moisture that will pass through it under normal conditions is decreased, and the detrimental effects of moisture are thereby lessened and the life of the paint extended.

The fact that a paint film of more uniform thickness can be applied with the spray gun than with the brush tends to make the spray gun more economical in the use of paint. This is offset to some extent by the effect of wind and weather conditions on the spray. In extreme cases it has been found to be practically impossible to use the spray because of an excessive amount of paint being blown away and lost. However, the consensus of opinion seems to be that, under general conditions, the spray gun is more economical in the use of paint than the brush.

As previously stated, the chief advantage in the use of spraying equipment over brush painting is the great saving in time and labor cost. The estimates of this saving run all the way from 10 per cent to over 50 per cent of the cost of hand brush painting on the same work, depending on conditions, with the average about 35 per cent. This is why the use of spraying equipment is developing so rapidly in railroad work. Practically every railroad from which information on this subject was obtained, stated that their future policy will be to use paint spraying equipment wherever it is possible to do so.

Conclusions

In view of the fact that the use of paint spraying equipment is developing so rapidly on American railroads, it is considered inadvisable to make any definite recommendations regarding its use or the organization of paint forces at the present time.

Appendix E

(10) ORGANIZATION FOR THE USE AND MAINTENANCE OF BALLAST CLEANING MACHINES AND CONDITIONS UNDER WHICH EACH PARTICULAR TYPE MAY BE USED (INCLUDING MOLES, SCREENS, LOCOMOTIVE CRANES, AND PLOWS USED IN CONJUNCTION WITH BALLAST DISCERS), COLLABORATING WITH COMMITTEE XII—RULES AND ORGANIZATION

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A brief outline sketching the history of ballast and the necessity for cleaning it may form a useful background. When railroads were first introduced into this country about one hundred years ago, the method of construction followed the practices originated in England. There railways had first been used to bring wagons loaded with coal from the mines located near the sea coast down to the ship side. They consisted of tracks formed of longitudinal stringers of wood with a raised edge to keep the wheels on the rails. Later cast iron grooved plates were used on top of the stringers, as the wood wore out very fast; and then some genius put a flange on the wheels and lengths of strap iron on the stringers. Much of the early construction in this country was of that type. When the Commonwealth of Pennsylvania began the building of the Public Works in 1829, consisting of a line of railroads and canals stretching across the State from Philadelphia to Pittsburgh they adopted rails resting in chairs bolted to stone blocks set in the ground, but on account of our cold northern winters the heaving by the frost threw the tracks out of gage, and it was found necessary to tie the two lines of rails together. This was done by replacing every third pair of stone blocks by a long stone laid crosswise of the track. But these stone ties were expensive and wood was plentiful and cheap so wooden cross-ties came into being.

In 1830, Robert Stevens, the President of the Camden & Amboy Railroad, went to England to secure a supply of rails for the line being built across New Jersey, and while on shipboard he whittled out of wood a sample cross-section of the rail he wanted and designed the hook-headed spike, both of which items of our track structure remain practically unchanged to-day, except as they have grown in size.

The early railroads built in this country were constructed with very little if any ballast, the ties being laid on top of the ground as soon as the grading was done. As traffic increased, however, the ties sunk in the mud and eventually cinder and gravel and finally, for the more important lines, broken stone ballast was found to be necessary. For many years the depth of ballast under the ties was small, and the mud worked up between the stones and it was the practice to drag new ballast and raise the tracks, thus improving the drainage and permitting the water from rains and melting snow to run away.

The early locomotives were equipped with so-called "diamond stacks" containing netting and devices for breaking up large sparks and cinders to avoid setting fire to nearby fields and buildings. In order to minimize this danger, the extension smoke box was developed and a large proportion of the sparks and cinders were caught and retained on the engine instead of being discharged to the atmosphere. But as trains grew

heavier and locomotives more powerful and larger amounts of coal per hour were consumed, it was found that the extension smoke boxes were not large enough to retain the sparks, and the self-cleaning front end was perfected. This meant that quantities of unconsumed coal and cinders were thrown out of the stacks and fell back on the right-of-way and when added to the fine coal from leaking hopper cars, ashpans that did not close tight, sand and other fine material sifting down on the tracks, the drainage was soon obstructed and pumping ties the result. Furthermore, the difficulty of raising tracks at station platforms and the impossibility of doing so at overhead crossings, through bridges, etc., has made it necessary to clean ballast instead of continually raising the tracks out of the dirt on new material.

The earliest method was the ballast fork operated by hand labor, but the work was tedious and costly, and was rarely carried deep enough below the bottom of the tie to be really effective. In 1911, the first experiment was made with means for cleaning ballast mechanically and in 1919 a machine was brought out which operated in the center ditch and did not obstruct the adjoining tracks. The Pratt patent covering this method of working is one of the few fundamental or basic patents which has been obtained in recent years. This machine was too flimsy and it failed frequently on account of breaking of various parts, and its development was abandoned. A little later, one of the Eastern railroads experimented with their ditchers (Fig. 1) using the clamshell bucket

FIG. 1—DITCHER BALLAST CLEANER.

to lift the dirty ballast from the center ditch and pour it over a screen set at an angle of 45° on top of a gondola car, the dirt falling through the screen into the car and the cleaned stone running over the side of the car back into the track. This was the first successful method of mechanically cleaning ballast. It soon spread from the Pittsburgh district where it originated and by working with several units in a train and using gasoline instead of steam cranes, it is still one of the cheapest methods of cleaning ballast.

The total cost with interest at 6 per cent, depreciation 10 per cent, annual overhaul 10 per cent, operating expenses, wages, fuel and supplies, etc., is from 8 cents to 11 cents per lin. ft. of center ditch cleaned. The depth cleaned is usually from 12 in. to 16 in. below the bottom of the tires, and the wide variations in cost are due to the in-

terruptions caused by traffic on the adjoining tracks, length of run from the layover point, etc.

In the meantime other experimenters were at work and various schemes were tried. Revolving and shaking screens fed by hand-shoveling were used, and the vacuum and revolving brush sweepers were built. A very large vacuum machine was tried in 1925 but found unsatisfactory, and in 1926 the "Mole" type was brought out (Fig. 2 and 3). A very considerable number of these machines are in use by various railways, mostly in the East, and they have the great advantage of doing their work without obstructing a track. In multiple track territory conveyors can be used to carry the dirt across one track and border "Moles" are now available for cleaning the shoulder.

The total cost of operating "Moles" in the center ditch with all items of expense included, varies from 8 cents to 12 cents per linear foot, and the average production is about 15 miles per season. They usually clean from 8 in. to 10 in. below the bottom of the ties and on busy railroads there is considerable interruption caused by passing trains. But they do not interfere with traffic, and on many roads are a preferred machine on that account. Border "Moles" operate at a cost of 3 cents to 6 cents per linear foot.

In 1927, a large special machine was built for one of the Eastern roads and this has proved to be a very satisfactory unit (Fig. 4 and 5). It consists of two steel underframe cars, the front one provided with two clamshell buckets operating in curved guides, both on the same side of the car and spaced about 15 ft. apart. The buckets open 8 ft. and the car is moved forward about 6½ ft. at a time. The outfit is provided with two power plants, the main one a 250 H.P. gasoline engine driving a 250 volt generator, and an auxiliary of smaller size for furnishing current during the eight hour layoff trick when the overhauling is done. All functions are motor driven, each of the buckets being controlled by an operator, and the train moved forward about 6½ ft. each time by an electric winch with another operator. The locomotive which takes the train from the layover point to the place where the work is to start cuts loose from the front car and a sheave block is attached to the coupler. The locomotive then moves away from the train several hundred feet, unwinding the wire rope from the haulage drum. Brakes are then applied and the engine serves as a "dead man" until the train has moved up to it. The dirty ballast dug out of the center ditch by the clamshell buckets is raised and poured into hoppers near the center line of the car and under these two hoppers passes a conveyor which transports the material to the rear, elevating it and discharging it into a chute which spans the gap between the two cars. At the front end of the second car is a vibrating screen of ¼ in. wire with the meshes 1 inch clear opening, and as the dirt falls through, it is conveyed to the rear and elevated to a chute spanning the gap to the following car. The clean stone is delivered to a chute which feeds it from the side of the car back into the center where it is shaped by a scraper into the contour desired. Seven cars are usually carried in the train for receiving the dirt, these being the standard four-hopper coal cars of 140,000 lb. capacity. Each is equipped with a scraper conveyor, motor driven, running lengthwise over the top of the car and there are openings in the bottom of the conveyor with gates which permit loading the car at several points. The conveyors are removed from the loaded cars to a string of empties at the layover point, using a crane built onto the outfit for that purpose.

It is customary to work this ballast cleaning machine for 16 hours, changing crews in the middle of the period and then running to the layover point for changing conveyors, shifting out the loads, receiving fresh supplies of gasoline and oil, making minor repairs, giving lubrication the necessary attention, etc. Unless the ballast is too wet, the usual speed of operation is three grabs per minute, moving forward about 20 ft. or from 1,000 to 1,200 feet per hour without any interruptions. However, cables sometimes

Fig. 2—Front View Center Ditch Mole.

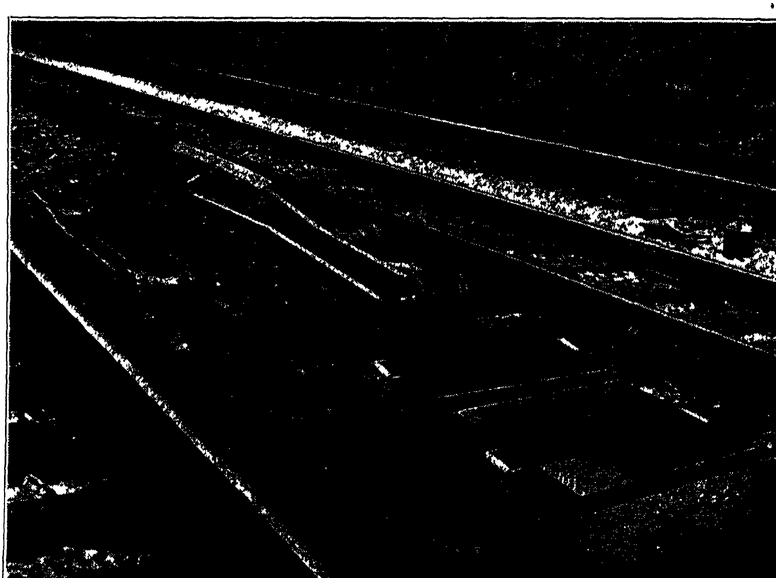

Fig. 3—Rear View Center Ditch Mole.

FIG. 4—SPECIAL BALLAST CLEANING MACHINE SHOWING BUCKETS.

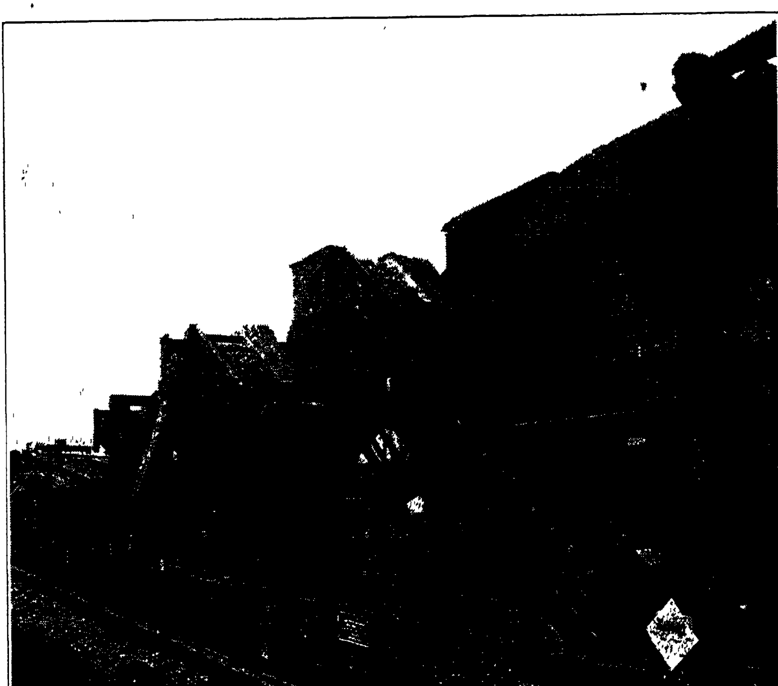

FIG. 5—SPECIAL BALLAST CLEANING MACHINE SHOWING ELEVATORS AND SCREENS.

break, and various minor repairs are needed on the job, so that this speed of advance cannot be counted on continuously. Furthermore, when trains are passing on the adjoining track on the side where the buckets are operating, the work must cease and the maximum production so far obtained is 256,000 linear feet of center ditch cleaned in a month, working two tricks per day and laying off one day a week.

The machine costs $150,000 complete, and with interest at 6 per cent, depreciation at 12 per cent (which is the weighted average) and annual overhaul at 10 per cent, the total cost including operating expense, train and engine crew wages and expenses, locomotive rental, fuel and supplies, etc., is about 6¼ cents per foot. The working season is eight months. The first machine built has been operated on a rental basis and two more recent machines are owned by an Eastern road.

In 1930, a ballast cleaning machine (Fig. 6) was designed and tried out on one of the Eastern roads, and during 1931 it cleaned about 200 miles of center ditch on another

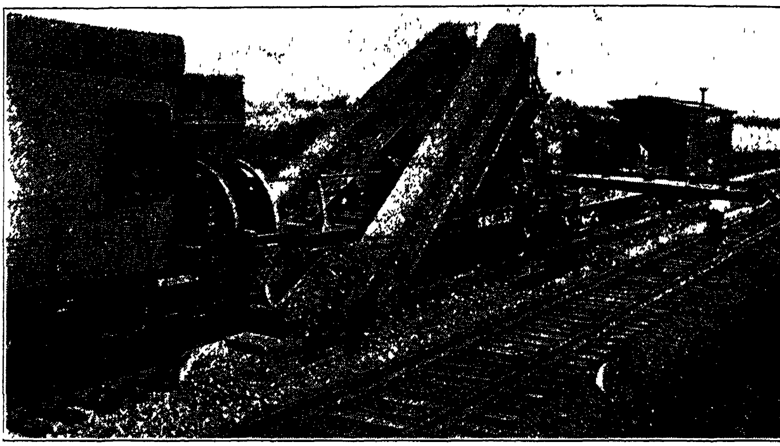

Fig. 6—Ballast Cleaning Machine.

road. The machine is mounted on a special steel frame flat car followed by an idler and pulled by a gas-electric or steam locomotive. It operates at a speed of about 50 ft. per minute and is a double sided outfit, i.e., it can clean on both sides of the track on which it is moving; and with the present machine a minimum of 12 ft. 9 in. center to center of tracks is required in order that the machine be continued in cleaning operations without interfering with traffic on the adjacent track.

The ballast is lifted by a scoop or flat nosed plow, which is essentially a box about 24 in. wide with two sides and an inclined bottom without top or ends. This can be lowered down over the side of the car and set at any desired depth down to 29 in. below the top of rail, usually operating 8 in. or 10 in. below the bottom of the ties. As the car moves forward the ballast is crowded up the slope and falls over the end on to a short inclined belt conveyor over the upper end of which it falls to a long belt conveyor which rises toward the rear of the car and pours the dirty ballast over a vibrating screen. The cleaned ballast can be delivered between the rails or back into the center ditch. The dirt is delivered to an 18 in. belt conveyor supported by a 23 ft. boom, which is pivoted under the dirt hopper and can be swung out on either side of the car.

On a three track railroad when the machine is operating on the middle track, the dirt is delivered beyond the outside shoulder on the adjoining track.

Following the front scoop, which must be set far enough out to miss the long ties, is a plow, riding against the ends of the ties under spring pressure, and this removes whatever material is left immediately along the ends of the ties and delivers it across the ditch to the center line of the intertrack space. The cleaned stone can then be deposited in this excavation and the machine is placed on the adjoining track and another trip run. This results in some dirty ballast being crowded over on to the portion already cleaned, so a third trip is run over the track first operated on in order to get out all the dirt. In case of very dirty ballast a fourth and sometimes a fifth trip is run, if necessary.

The operating crews consist of three men, the power plant being a 30 H.P. gasoline engine; and all functions of raising and lowering the scoops and plows and retracing the lower ends of the conveyors toward the center line of the car are controlled by friction clutches and levers grouped in a cab at the front end of the car.

The machine has been operated on a rental basis at a cost of 5 cents per linear foot of center ditch cleaned, and the railroad expense for engine and train crew wages, locomotive, etc., is 1½ cents per foot, making a total cost of 6½ cents per foot.

Previous to the advent of the border "Mole" a good deal of work had been done on discers, plows and scarifiers. Some means of working over the shoulder is needed in the Spring, in order to break down the dam of mud which forms around the ends of the ties, and let the water drain out. After two or three weeks' exposure, the ballast has dried out and the modern powerful self-propelled discer will turn over the gravel, working the dirt to the bottom, and build up the shoulder again with clean material. A machine will do about 125 miles of border in a season, at a total cost of $7.00 per mile. Experiments have been tried in an effort to develop a machine for cleaning and reshaping the border. It is expected that the cost of operation will be 3 cents or 4 cents per linear foot of border.

No machine has yet been perfected for cleaning the cribs. A skeletonizer was brought out a few years ago which worked fairly well in gravel ballast, but it failed in stone, and the cost of operation and maintenance was unduly high.

The organization for the use and maintenance of ballast cleaning machines is shown in the following table.

Appendix F

(12) THE USE OF OIL SPRAYING MACHINES FOR OILING RAILS AND FASTENINGS, STEEL STRUCTURES AND ROADBED

Fred Zavatkay, Chairman, Sub-Committee; O. L. Beydler, J. A. Cochran, S. E. Coombs, C. L. Fero, Paul Hamilton, L. C. Hartley, P. R. Henderson, F. W. Hillman, G. W. Hunt, R. A. Morrison, A. J. Neafie, E. H. Ness, C. H. Paris, G. L. Sitton, N. M. Trapnell.

Cost of replacement of present-day track and roadbed is recognized as the most important item of maintenance expense, and the sums involved are so enormous that any successful effort to prolong the useful life should receive serious consideration

By reason of its location, track-steel suffers a rapid deterioration, due to natural elements which create rust, dust and friction.

The causes of rust in track-steel are:

1. Moisture.—Track-steel located close to roadbed is always exposed and moist roadbed causes the rusting of unprotected track-steel.

2. Drippings From Locomotives.—Locomotives and coal-carrying cars permit drippings which usually contain sulphur, and which are frequently hot, to fall on track-steel—this causes rust formation.

3. Locomotive Gases.—Gases expelled from locomotives settle on track-steel and result in steel corrosion.

4. Refrigerator Brine Drippings.—Track-steel is exposed to drippings from refrigerator cars and the effects cause rapid deterioration.

5. Ocean Brine or Fog.—Track-steel exposed to ocean brine deteriorates rapidly.

6. Manufacturers Fumes.—Track-steel is exposed to fumes from manufacturing plants and causes steel corrosion.

Some of these agencies are affecting nearly every pound of steel in every mile of track structure, and in many cases deterioration is extremely rapid when all of these agencies are present.

When considering the amount of steel for one mile of single track laid with 110 lb. rail, exclusive of any special work, assuming that it represents approximately 222 tons, the losses resultant from rust average 2.7 tons per annum which will be noticed in the reduction of sectional area and in the weight of the steel when it is finally sold for scrap. Also considering the enormous resultant damages in loss of strength and in failure of track structure due to rust which are impossible to accurately estimate, it will be conceded that measures adapted to curtail losses are necessary and economical.

Rust Prevention by Oil Application

For effective results rust preventative must be applied to track-steel while in its place in the track structure and should be properly applied annually. Authorities recognize asphalt base oil containing approximately 50 per cent to 60 per cent asphaltum as the most effective and most economical for protective coatings to prevent rust. Such oil should possess the following characteristics. It should be clean and free from foreign material and injurious ingredients, and it must have a high flash-point. The consistency should be sufficiently light to give it high creepage when spreading has taken place. After application it should harden within reasonable time to prevent excess dust-collecting, and should remain in elastic condition to prevent peeling under wave action of rails.

Methods of Application

The most practical and economical method of application of oil to track-steel as a rust preventative is the pressure-spray method. Hand applications are slow and impractical, even for joint oiling, and gravity applications are unsatisfactory. There are several railway track oilers available for use, self-propelled and non-self propelled.

Seventeen replies to questionnaires soliciting data from various railroads indicate twelve railroads now use oil-spray equipment.

An excess of oil is of great advantage as it allows for creepage to unexposed portions and forms a much heavier coating which is more durable than is obtained from scanty applications. However, a maximum should be established for the most satisfactory results.

Roadbed Oiling

For track ballasted with cinders, pit-run gravel or chatt, the oiling of roadbed is desirable for the following reasons:

(1) Practically eliminates dust.
(2) Preservation of ties.
(3) Prevents growth of weeds, particularly after two or three annual applications, and a firm heavy coating has been acquired.

As shown in the table, it will be noted that there is a large variation in the cost and in the quantity of oil used per mile of single track roadbed oiled. For subsequent treatments, preferably in the early Spring or Summer, 400 to 600 gallons per mile applied in one application will produce satisfactory results.

As a weed killer, roadbed oil as applied with pressure spray equipment will kill off present growth and retard future growth. This feature alone justifies a portion of the expense involved for oiling roadbed.

Railway	Gals. oil applied per mile single track, joints only	Gals. oil applied per mile single track, rail and fastenings	Gals. oil applied per mile single track, roadbed	Cost per mile single track oiled, joints only	Cost per mile single track oiled, rail and fastenings	Cost per mile single track oiled, roadbed
Illinois Central	16.6		328	$2.17	$5.64	$5.64
Missouri Pacific	10	157		1.20	6.07	6.07
Chesapeake & Ohio	2.07	80	654	1.46		26.68
Pennsylvania	20			3.00	7.00	
Chicago & Northwestern	18	100		2.39	7.37	
C. C. C. & St. L.		104			6.40	
Delaware, Lackawanna & Western		84			6.97	
N. Y. N. H. & H.		94	450		9.88	17.33
Union Pacific		221	1104		12.08	44.71
Boston & Maine		122	641		9.06	26.59
A. T. & S. F.		115			9.80	
Erie		86			3.57	

	Self-propelled oil sprayer	Non-self propelled oil sprayer	Joints and rail fastenings oiled	Road-bed oiled	Roadbed, joints and and fastenings oiled in one operation	Heat oil applied	Non-heat oil applied
Illinois Central	x		x	x	x	x	
Missouri Pacific	x		x	x	x		x
Chesapeake & Ohio	x	x	x	x		x	
Pennsylvania	x		x			x	
Chicago & Northwestern	x		x			x	
C. C. C. & St. L.		x	x			x	
Delaware, Lackawanna & Western		x	x			x	
N. Y. N. H. & H.		x	x	x		x	
Union Pacific	x	x	x	x		x	
Boston & Maine		x	x	x		x	x
A. T. & S. F.	x		x				
Erie		x	x			x	

REPORT OF COMMITTEE XXI—ECONOMICS OF RAILWAY OPERATION

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BARTON WHEELWRIGHT,
C. C. WILLIAMS,
JOHN S. WORLEY,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

1. Revision of Manual, including revision of the method for the determination of proper allowances for maintenance-of-way expenses due to increased use and increased investment.

2. Methods for obtaining a more intensive use of existing railway facilities, with particular reference to securing increased carrying capacity:
   (a) Without material additional capital expenditures;
   (b) With due regard to reasonable increases in capital expenditures consistent with traffic requirements.

3. Methods or formulas for the solution of special problems relating to more economical and efficient railway operation.

4. Most economical makeup of track to carry various traffic densities, collaborating with Committees I—Roadway, II—Ballast, III—Ties, IV—Rail, V—Track and X—Signals and Interlocking.

5. Methods for determining most economical train length, considering all factors entering into transportation costs, collaborating with Division I—Operating, A.R.A.

6. The effect of volume of traffic on railway operating expenses.

Action Recommended

Your Committee desires to report progress concerning Assignment No. 5, and that:

1. The report of Sub-Committee, Appendix A, be received as information and the subject continued.

2. The report of Sub-Committee, Appendix B—Part 1, be received for publication in the Manual. The Appendix B—Part 2, be received as information, and the subject be continued.

3. The report of Sub-Committee, Appendix C, be received as information and the subject continued.

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4. The report of Sub-Committee, Appendix D, be received as information and the subject continued.

6. The report of Sub-Committee, Appendix E, be received as information and the subject continued.

Respectfully submitted,

THE COMMITTEE ON ECONOMICS OF RAILWAY OPERATION
J. E. TEAL, *Chairman.*

Appendix A

(1) REVISION OF MANUAL, INCLUDING REVISION OF THE METHOD FOR THE DETERMINATION OF PROPER ALLOWANCES FOR MAINTENANCE OF WAY EXPENSES DUE TO INCREASED USE AND INCREASED INVESTMENT

J. F. Pringle, Chairman, Sub-Committee; S. W. Fairweather, J. M. Farrin, C. H. R. Howe, E. E. Kimball, M. F. Mannion, C. E. Smith, C H. Stein.

Your Committee is of the opinion that since the material under the heading "Method for the determination of proper allowances for Maintenance of Way Expenses due to increased use and increased investment" was adopted as printed in the 1929 Manual, changed conditions covering maintenance practices may or may not affect the use factors relating to:

Tunnels and subways	Account	206
Bridges, trestles and culverts	"	208
Ties	"	212
Ballast	"	218
Track laying and surfacing	"	220
Signals and interlockers	"	249
Roadway machines	"	269
Small tools and supplies	"	271
Removing snow, ice, etc.	"	272
Shop machinery	"	302
Power plant machinery	"	304

This question has been taken up with various Committees that may be affected and it is hoped that conclusions will be reached in order to enable this Committee to offer recommendations at the annual convention in 1933. The Committee recommends that the subject be continued.

Appendix B

(2) METHODS FOR OBTAINING A MORE INTENSIVE USE OF EXISTING RAILWAY FACILITIES, WITH PARTICULAR REFERENCE TO SECURING INCREASED CARRYING CAPACITY:

(A) Without Material Additional Capital Expenditures
(B) With Due Regard to Reasonable Increases in Capital Expenditures Consistent With Traffic Requirements

M. F. Mannion, Chairman, Sub-Committee; B. T. Anderson, R. B. Ball, R. C. Bardwell, J. H. Dyer, S. W. Fairweather, G. D. Hughey, E. E. Kimball, H. Rhoads, L. S. Rose, J. B. Schwendt, R. E. VanAtta, Barton Wheelwright.

PART I

Studies have been undertaken and published in the Proceedings to test out the theory of train hour diagrams and obtain experimental knowledge that will serve to extend the scope of the method in connection with the investigation of factors affecting freight train operation. They indicate that comparative freight train performance charts provide a simple and accurate method for showing actual results obtained by various methods of operation or changes in facilities. From these studies the following conclusions have been drawn—

A. (1) It has been found that freight train operations can be represented by a mathematical law (A.R.E.A. Proceedings, Vol. 32, page 641).

(2) The application of this law to different sets of observations make it possible to compare several months' operation of a given division on a more equal basis. Likewise, operations of different divisions which are more or less similar can be compared on more nearly the same basis (A.R.E.A. Proceedings, Vol. 32, page 641).

(3) By such comparisons the effect of extreme weather conditions, greater facilities, motive power, different commodities and supervisory methods on the average time on the road can be more accurately determined (A.R.E.A. Proceedings, Vol. 32, page 641).

B. (1) Increased supervision, consisting of scientific study and thoughtful effort, will increase the capacity of a railway (A.R.E.A. Proceedings, Vol. 26, page 878. Vol. 32, page 641).

(2) Increasing capacity of locomotives results in an increase in the capacity of the railway (A.R.E.A. Proceedings, Vol. 26, page 878. Vol. 32, page 641).

(3) Double tracking will increase the capacity of a railway—the increase in capacity being proportional to the amount of second track. Careful study should be given to practicability of increasing capacity of single track and obtaining more intensive use of same, either by increased supervision and study of operations, signals, etc., before constructing double track (A.R.E.A. Proceedings, Vol. 24, page 1046; Vol. 27, page 746; and Vol. 30, page 752; Vol. 32, page 641).

(4) Installation of automatic signals on a single track railway will increase the capacity of the road—this increase varying with the length of the division on which installed and with the number of passenger trains operated (A.R.E.A. Proceedings, Vol. 27, page 739; Vol. 31, page 1003; Vol. 32, page 641).

(5) Installation of centralized traffic control system on a single track railway will increase the capacity of the road. This method of increasing capacity should be considered when the volume of traffic justifies or when other conditions necessitate (A.R.E.A. Proceedings, Vol. 31, page 1010; Vol. 32, page 641).

(6) Use of large engine tanks or water cars will increase the capacity of the railway by eliminating delays and permitting greater movement of traffic over the same district (A.R.E.A. Proceedings, Vol. 29, page 193; Vol. 30, page 754; Vol. 31, page 1010).

The Committee recommends that the above conclusions be approved for publication in the Manual.

PART 2

CONVERTING DOUBLE TRACK INTO SINGLE TRACK

History

The primary object of this Committee's work has been to study the effects of various changes in operating conditions upon freight train performance and to determine the extent to which these changes increase the traffic capacity of a railway. This year the Committee submits a report of a study made on the East and West Railroad on the effect of removing 24.6 miles of track on a 62.5-mile section of road where traffic has been reduced from a total of 30 trains—freight and passenger—per day in 1920, to 12.6 trains—freight and passenger—per day in 1930.

The above traffic density figures were taken from train sheets available, which records prior to 1920 have been destroyed. However, information furnished by old employees indicate that the greatest traffic density (Number of trains per day) was about the year 1911, when the maximum number of trains operated ranged between 50 and 60 per day, which required double track operation at that time. This included trains operated by a foreign line having trackage rights over this section of road.

Present Track Plan

Fig. 1 shows the present track plan and profile of the section of the East and West Railroad, between A and B, which was studied. Of the 62.5 miles of road, 27.5 miles of road between A and C and F and G, are single track and 35 miles between C and F and G and B are double track, the double track sections having been installed between the years 1881 and 1911. Point A is located at an interlocking plant at the end of double track, at a railroad grade crossing adjacent to a large freight yard, while Point B is at the present end of double track and junction with a foreign railway. At D, there is a non-interlocked grade crossing with a foreign line. Between A and C, there are five passing sidings in the single track territory. There is one siding on the single track between F and G, but it is seldom used for meets or passes. Grades are from .1 per cent to .6 per cent.

Traffic

The heaviest traffic in recent years was in 1920 with an average of 30 trains per day —24 freight trains of 50 cars, averaging 2,500 gross tons, and 6 passenger trains. In 1930, there was an average of 8 freight trains of 42 cars each and 4 passenger trains. In July 1931, there was an average of 7.9 freight trains of 58 cars, averaging 2,777 gross tons, and 4 passenger trains per day.

The tonnage movement and freight train performance for 1930, exclusive of local and foreign freight service was:

MANIFEST FREIGHT SERVICE

Item	*Eastbound*	*Westbound*	*Average*
Gross Train Load	1,239	2,334	1,747
Number of Trains per Day	1	.86	1.86
G.T.M. per Crew Hour	15,586	25,132	20,384
Average M.P.H.—Road	15.3	12.4	13.8
Average M.P.H.—Crew	12.6	10.8	11.7

SLOW FREIGHT SERVICE

Gross Train Load	2,090	3,669	3,008
Number of Trains per Day	1.21	1.37	2.58
G.T.M. per Crew Hour	25,655	37,830	32,710
Average M.P.H.—Road	14.5	11.0	12.4
Average M.P.H.—Crew	12.2	10.4	11.2

While the average slow freight train load was 3,008 tons, during January, 1930, some heavy tonnage trains of 82 cars, 7,000 gross tons were operated when tonnage was available.

Power

In general, the same class of power has been used since 1920, the tractive effort being 67,076 lb. to 72,628 lb.

Operation of Trains

Trains are operated on the present line by timetable, train order and manual block. At the majority of the stations on single track, there are two sets of manual block signals for providing an additional short section of manual block territory for facilitating train movements approaching a station when the station block is occupied.

Between E and D, about 17.5 miles, the north main track is used as a running track for westbound freight trains exclusively. Westward passenger class trains, or extra westward trains running on special schedule and eastward trains of whatever class, use the south main track. Manual block signals are not provided on the westward freight running track.

Maximum speed is 50 miles per hour for passenger trains and 30 miles per hour for freight trains.

There are 15 combination agency-block stations in the 62.5-mile territory, 5 being operated three tricks per day, 5 operated two tricks and 5 operated one trick per day.

At A, the crossover at the end of double track is power operated and protected by interlocking signals. At C, D, F and B, the switches at the ends of double track are handled by the telegraph operators. At G, there is a spring switch layout with color light home and distant signals controlled from H, 3.2 miles away. Westward distant signals interlocked with the switch at the ends of double track are provided at C and D.

At D, all trains are required by State law to stop at non-interlocked railroad crossing at grade.

There has been a sixty per cent drop in the number of trains operated on the A-B Sub-Division between the years 1920 and 1930, while in 1931 there has been a lesser number of trains operated and there appeared to be very little chance of an early increase in business in this territory. The passenger business has steadily decreased and will probably never return to the former traffic density.

Factors to be Considered in Converting Double Track to Single Track

It is apparent that under these diminishing traffic conditions and the necessity for providing economical transportation that in studying the effect of converting a portion of the double track into single track, due consideration should be given to the following factors:

1. Present and Proposed Track Plans.
2. Expenditures Necessary in Connection with the Track Changes:
   (a) Present Traffic.
   (b) Increased Traffic.
3. Effect of Converting Double Track to Single Track on:
   (a) Track, Bridge and Other Maintenance.
   (b) Taxes.
   (c) Train Operation.
   (d) Cost of Transportation.
   (e) Track Capacity.
4. Method of Directing Train Movements.
   (a) Timetable, Train Order and Manual Block.
5. Annual Savings and Return on Expenditures.

After the foregoing factors have been given due consideration, and a summary has been prepared, a conclusion can be drawn as to the feasibility of the proposed change.

Proposed Track Plan

Fig. 1 shows the profile, the present track plan and the proposed track plan for present business.

The proposed track plan, removes the westward running track between E and D, a portion of the second track between B and H and contemplates the following additional changes:

(a) Removes 3 existing short passing sidings, and provides 3 new longer passing sidings.
(b) Retires 10 crossovers and moves 1 crossover.
(c) Moves 8 switches leading into industry spurs.
(d) Adds manual block signals at ends of new double track at D, E and H.
(e) Changes flasher signals near H from double track to single track operation.
(f) Changes water facilities at E and F account of new track layout and method of train operation.

The proposed track plan retires a total of 130,000 feet of track (about 24.6 miles) from the present trackage.

This plan was arrived at after a careful field inspection by members of the Committee, including the Operating, Engineering, Maintenance and Signal officers of the East and West Railroad.

Three sections of double track are left in service between C and D, E and F, and G and H, where interchange, branch line, yard and switching movements are involved, and where experience has shown that double track is necessary to eliminate delays which would occur if entire single track operation is provided.

Estimated Cost of Retiring Portion of W. B. Main Track and Making Changes Between A and B

Item	*R. & E.*	*O. E.*	*P. & L.*	*Total*
Track and other changes	$20,670			
Operating expenses account of changes		$4,665		
Profit and loss, labor removing facilities retired and not replaced....			$27,485	
Cash expenditure	$20,670	$4,665	$27,485	$52,820
Retiral at current prices:				
Cross-ties replaced by switch ties.....	Cr. 1,055	1,055		
Retiral at ledger value:				
Track, bridges, crossovers, etc......	Cr. 585,615		585,615	
Salvage:				
Track material and bridge steel.......		Cr. 320	114,000–Cr.	114,320–Cr.
Total	Cr. $566,000	$5,400	$499,100	$61,500–Cr.

This estimate shows that the change in track plans for handling present business, based on the removal of about 24.6 miles of track, will require a cash expenditure of $52,820, and will result in a credit to Capital Account of $566,000, an Operating Expense of $5,400, a Profit and Loss Expense of $499,100, and, due to the salvage of $114,320 from track and bridge material, a total credit of $61,500. In other words, the retirement of 24.6 miles of track will result in a net return to the railway of $61,500, as actual cash will be received for the material sold as scrap and material fit for use can be applied at other locations instead of purchasing new material.

The effect of the reduction in Capital Account and charges to Operating Expense and Profit and Loss will require special consideration on each individual railroad. The report of this Committee is confined only to the effect on transportation and maintenance costs. It is evident that such a large reduction in investment account may be a major consideration on some railroads.

Effect of Converting Double Track to Single Track

(a) Decreased Cost of Maintenance.

The estimated reduction in annual maintenance cost of the proposed track plan compared with the present track plan, is as follows:

Item	*Present*	*Proposed*	*Saving*
General Maintenance	$148,639	$120,820	$27,819
Bridge Maintenance	721	360	361
Total	$149,360	$121,180	$28,180
Additional Signal Maintenance		300	—300
Total	$149,360	$121,480	$27,880

The reduction in annual maintenance cost of $27,880 for 24.6 miles of track, or about $1,130 per mile, appears low. This is accounted for by the fact that the larger part (70 per cent) of the second track to be removed is used as a running track rather than maintained as a high speed passenger and freight track, and that some of the existing second track replaces three sidings. Ordinarily, the reduction in annual maintenance

will vary from $1,200 to $2,500 per mile of track, depending on the local conditions on each railroad.

(b) Decreased Taxes.

A reduction of 24.6 miles of track is estimated to reduce taxes approximately $3,000 per year.

(c) Train Operation.

The actual running time of the trains between points A and B was taken from the Dispatcher's train sheets for sixteen consecutive days during January, 1930, as this was considered a representative period for present business. The average freight trains per day including foreign line trains for this period was 8.6 and the average running time per freight train was 5 hours and 13 minutes. This average time includes not only the running time, but the delay time and work time, and is an average speed of 12 miles per hour. The speed is low due to the amount of pick-up work.

The regular average freight train movements per day, in the sixteen days studied, were as follows:

Location	*Number of Trains*
A to B	4 Manifest and Slow Freights
A to F	2 Local Freights
A to H	2 Slow Freights
F to B	2 Local Freights

The sixteen days used in computing the present average running time were re-dispatched on the basis of the proposed single track operation, with tracks and sidings as shown in Fig. 1 and with manual block signals for directing train movements. The result of this re-dispatching shows that the average running time on single track for present traffic (1930 basis of operation) would be 5 hours and 15 minutes, or an increase in time over double track operation of two minutes per freight train. This slight additional time is accounted for by the necessity for meets and passes on the new single track as compared with the present double track operation on a portion of the line. Actually, it is probable that the trains would make the same time under either track layout, as a slight re-arrangement of schedules on one train leaving Point "B" each evening would eliminate some interference and save delay time enroute to Point "A". The scheduled meeting point is now on double track, and with one track removed, a change of schedule would advance the meet to double track.

(d) Cost of Transportation.

In order to determine the effect on the cost of transportation, it was first necessary to select a suitable unit for comparing the results of the different operating methods. Last year this Committee suggested that the cost per gross ton mile was the most suitable unit for comparing freight service costs. In this study, however, it was not practicable to obtain gross ton mile cost except by a calculation on the basis of estimated cost per train hour. As the gross ton mile cost varies directly with the train hour cost and the effect of the various methods of operation can be accurately and mathematically expressed in train hours and train hour cost, the unit used in this study is the train hour.

The estimated cost per train hour of operating a slow freight train on the A–B Sub-Division varies from $14.38 to $15.20, exclusive of car repairs. For the purpose of this study it was agreed that the saved train hour value was not effected 100 per cent on such items as wages, lubricants, other supplies, and locomotive repairs, and, therefore, a

value of $8.00 per saved train hour was considered a fair value in determining the effect on the cost of transportation.

A count was made of the actual freight trains run in 1930, which was 2,940. Although 244 trains were operated during the 16 days studied in January, 1930, from which was taken the average running time per train, it was decided to use 2,940 as the annual number of trains in this study for present traffic.

On the basis of an average loss of two minutes per freight train, the increased cost of transportation, with single track operation, will be as follows:

2,940 × 2 divided by 60 equals 98 additional train hours.
98 × $8.00 equals $784.00, increased cost of operation.

(e) Track Capacity.

There is no question but what the proposed track plan with present business will be adequate for the average train movement of 8.6 freight and 4 passenger trains per day.

Comparison of Present and Proposed Methods of Directing Train Movements

(a) Timetable, Train Order and Manual Block.

The removal of 24.6 miles of track, with present traffic will not require any change in the present method of directing train movements. The heavier traffic of 1920, 30 trains per day, was operated under this method of directing train movements.

The number of block stations and the number of telegraph operators, and their cost of operation would be the same under single track operation, present traffic, as with the former double track operation. Actually in 1931, with decreased traffic, it has been possible to reduce the number of tricks per day over 1930 operation, but the same reduction would be possible under either track plan.

Annual Savings

In addition to the credit of $61,500 from salvage, the following annual savings would result from the single track operation:

Decrease in Track, Bridge and Signal Maintenance	$27,880
Decrease in Taxes	3,000
Total Gross Saving	$30,880
Less Increased Cost of Transportation	784
Total Net Saving per Year	$30,096

Even if the return of $114,320 from salvage is disregarded, single track operation under present traffic will result in a net return of $30,096 per year on the cash outlay of $52,820, or over 57 per cent on the investment. If the traffic does not increase in two years, this saving will more than equal the total cash expenditure and for every year after two years of present traffic, the railway will save $30,096.

Of the $52,820 cash outlay, $25,335 is incident to the change from double to single track, which makes possible the net saving of $27,096 per year. The remainder, $27,485, is incident to cost of salvage and necessary changes resulting from the abandonment of the second track. This thought is offered for consideration because a railroad having such a problem may not be ready to assume the retirement charges incident to the actual removal of the abandoned second track.

Cost Per Train for Retaining Existing Tracks

The approximate cost per train for providing the 24.6 miles of second track, which can be removed, is as follows:

Maintenance	$27,880
Taxes	3,000
Total Cost per Year	$30,880

For 2,940 trains per year, the cost per train for second track would be $10.50. At $8.00 per saved train hour, it would be necessary to save 1 hour and 19 minutes per train in the 24.6 miles in order to show a profit on keeping the second track in service.

Summary

Converting 24.6 miles of double track to single track on the 62.5-mile line of the East and West Railroad as proposed in this study, is estimated to effect the following results:

First—Expenditures and credits for track and other changes.

(a) Required a Cash Expenditure of $52,820.
(b) Reduce Capital Account by $566,000.
(c) Show a Profit and Loss Expense of $499,100.
(d) Show a Credit for Salvaged Material of $114,320.
(e) Result in a Net Credit of $61,500.

Second—Decreased Cost of Maintenance and Taxes and Effect on Cost of Operation and Transportation.

(a) Decrease Track and Other Maintenance $27,880 per year.
(b) Decrease Taxes $3,000 per year.
(c) Increase the average running time per freight train 2 minutes.
(d) Increase the cost of transportation $784 per year.

Third—Return on Investment.

(a) Show a Net Saving of $30,096 per year on the Cash Expenditure of $52,820 or 57 per cent on the investment.
(b) If traffic decreases, compared with 1930, the savings in 3 (a) will increase.
(c) If traffic increases, compared with 1930, the saving in 3 (a) will decrease and expenditures will eventually be necessary for additional facilities.

Conclusion

Where the volume and distribution of traffic on a double track line has decreased enough to warrant a reduction in facilities, the converting of double track into single track should be considered.

The Committee recommends that this report be accepted as information.

Appendix B

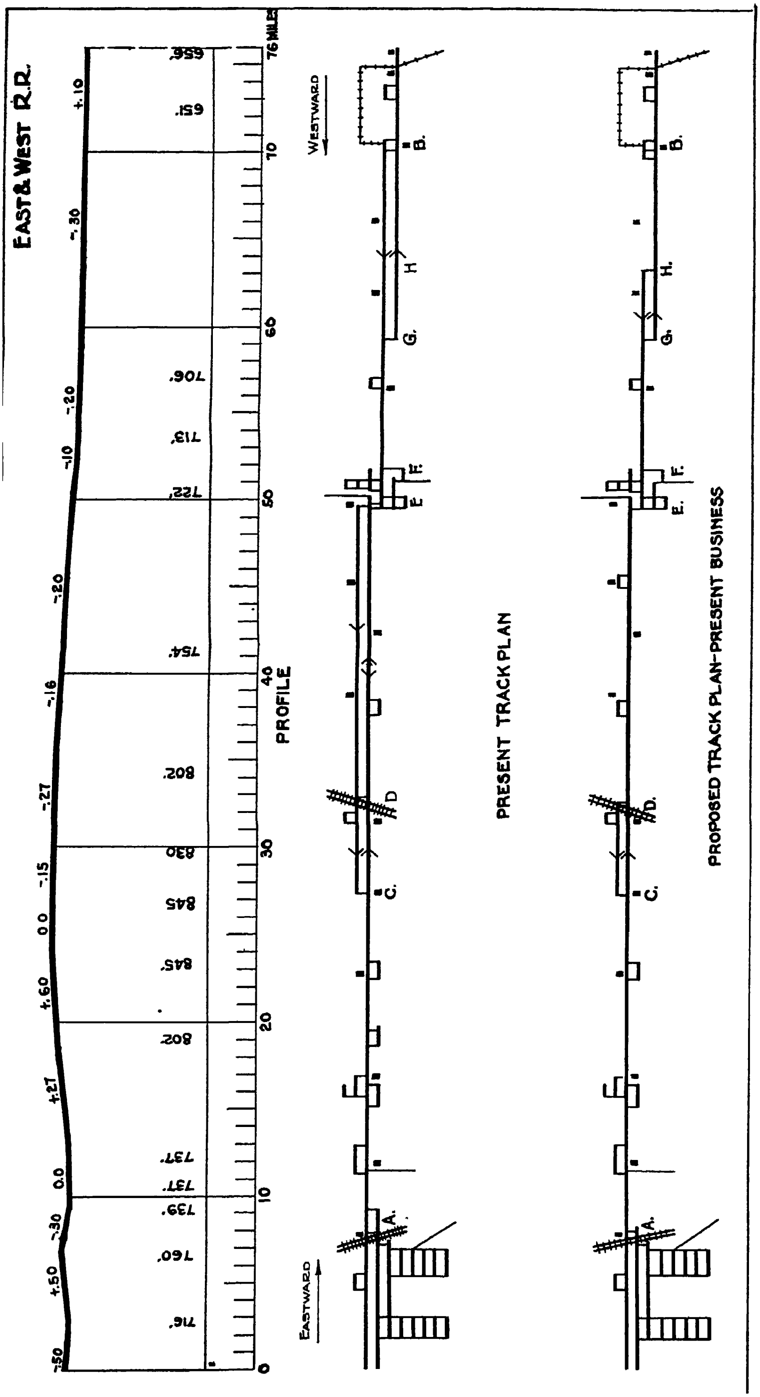


Fig. 1

Appendix C

(3) METHODS OR FORMULAS FOR THE SOLUTION OF SPECIAL PROBLEMS RELATING TO MORE ECONOMICAL AND EFFICIENT RAILWAY OPERATION

C. H. R. Howe, Chairman, Sub-Committee; B. T. Anderson, A. Lee Atwill, S. B. Cooper, W. N. DeRamus, C. C. Dougherty, G. W. Hand, W. W. Judson, Shu-T'ien Li, F. H. McGuigan, Jr., E. S. Pennebaker, J. E. Saunders.

During the past year, the Committee has given its attention to a preliminary study of the problems of operation as affected by curvature and rise and fall.

In many cases, the necessity for grade reduction or re-alignment is so obvious that almost any method of analysis will readily show the need of the change, and the results obtained will justify the investment. However, as we approach refinement in grade and curvature problems, necessity and benefit are not always so apparent, and the question of whether or not the same results can be obtained through other means becomes important.

Recent developments in methods of maintaining smoother riding track structure, the greasing of curves, which not only prolong rail life but reduces resistance to train haulage, are factors which now must be considered.

The Committee believes that there is need for investigation of the factors mentioned and we are now securing data on which our conclusions must be based. We further feel that more intensive study must be given to the effect of curvature and rise and fall on each of the accounts involved in operation. We have undertaken the examination of these accounts with view of presenting to the Association at a future date, a practical method for the solution of the class of problems outlined.

The Committee recommends that the subject be continued.

Appendix D

(4) MOST ECONOMICAL MAKEUP OF TRACK TO CARRY VARIOUS TRAFFIC DENSITIES

J. M. Farrin, Chairman, Sub-Committee; G. S. Crites, Z. A. Green, E. M. Hastings, E. L. Hoopes, C. H. R. Howe, Mott Sawyer, R. T. Scholes, C. C. Williams.

Considerable work has been done during the year accumulating data and arranging in diagrammatic form, but work is not complete for presentation. The Committee reports progress with recommendation that subject be continued.

Appendix E

(6) THE EFFECT OF TRAFFIC DENSITY ON OPERATING EXPENSES

S. W. Fairweather, Chairman, Sub-Committee; H. C. Crowell, Miss Olive W. Dennis, L. F. DeRamus, J. M. Farrin, G. W. Hand, E. M. Hastings, C. H. R. Howe, M. F. Mannion, P. J. Neff, J. F. Pringle, Mott Sawyer, W. P. Sloan, C. H. Stein, M. F. Steinberger, R. E. VanAtta, C. C. Williams, John S. Worley.

Your Committee has had under consideration and study the effect of traffic density on railway operating expenses.

The Committee is satisfied that certain broad and determinable factors underlie the fluctuations of railway operating expenses, which principles have a casual relation to traffic density. Analysis of statistical data applicable to all Class I roads of the United States, adjusted for changes in money values, give fairly consistent results, indicating that for moderate variations in traffic density, the expense of a road of the average traffic density of Class I roads of the United States and with average capital investment, may be considered to be 35 per cent fixed or independent of traffic and 65 per cent variable or fluctuating directly with traffic. While the correlation factors obtained in this analysis were quite high, your Committee wishes to point out that wide variations in traffic density could only be obtained by considering a time series and, therefore, some doubt is cast upon the result.

Attempts to confirm the general conclusion by the analysis of the results of individual roads as reported to the Interstate Commerce Commission failed and your Committee feels that, generally speaking, such analyses can only be undertaken by one having full knowledge of the variations in the detail accounts of the specific railway, otherwise the effect of the broad principles connecting traffic density with expense will, in individual years, be obscured by accidental and management factors.

The Committee recommends that the subject be continued.

REPORT OF COMMITTEE XXV—RIVERS AND HARBORS

E. A. HADLEY, *Chairman;*
W. J. BACKES,
GILBERT J. BELL,
A. F. BLAESS,
W. G. BROWN,
E. A. CRAFT,
A. F. CROWDER,
H. A. DIXON,
B. ELKIND,
W. D. FAUCETTE,
R. E. FRISTOE,
W. E. HAWLEY,
C. R. HOWARD,
W. L. MORSE, *Vice-Chairman;*
F. G. JONAH,
W. H. KIRKBRIDE,
R. J. MIDDLETON,
J. A. PARANT,
G. A. RODMAN,
R. O. ROTE,
E. H. ROTH,
C. U. SMITH,
W. C. SWARTOUT,
W. R. SWATOSH,
C. E. WEAVER,
R. C. YOUNG,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report on the subjects assigned as follows:

1. Definitions of terms (Appendix A).

It is recommended that the report be accepted as information and the subject continued.

2. Recommend suitable types of construction for levees, dikes and mattresses for use under varying service conditions, giving consideration to stream alinement, subsurface, soil or other local conditions (Appendix B).

3. Submit specifications for the construction of the several types of river bank protection in common use (Appendix B).

The report on subjects 2 and 3 for this year supplements and amplifies those submitted to the convention in 1930 and 1931.

It is recommended that the specifications submitted in 1931 covering loose fascine type mattress, board mattress, mud cells, riprap bank paving and anchor piling be adopted and approved for printing in the Manual.

That the specifications submitted with this year's report covering hydraulic fill levee construction; woven willow mattress; pole and brush bank mattress; pole, brush and rock dikes, and brush fascines be received as information and for further consideration of the membership and the subjects be continued for further study and investigation (Appendix B).

4. Describe different types of bulkheads, jetties and seawalls, giving cross-sections of each and stating the purpose which they serve, including comparisons of first cost, service life and maintenance cost of the various types (Appendix C).

5. Describe different types of fender systems for protecting wharves and recommend suitable uses for each, including comparisons of first cost, service life and maintenance cost of the various types (Appendix C).

6. Describe types of warehouse piers, coal and ore piers, car float piers and others with recommendation as to the type suitable for use under various conditions, collaborating with Committee XIV—Yards and Terminals, including comparisons of first cost, service life and maintenance cost of the various types (Appendix D).

7. Recommend size and depth of slips required for economical operation of the various types of wharves and traffic conditions, including comparisons of first cost, service life and maintenance cost of the various types (Appendix D).

8. Harbor structures (Appendix D).

Bulletin 341, November, 1931.

Recommended that the reports on subjects 4, 5, 6, 7 and 8 be accepted as information and the subjects be continued.

Respectfully submitted,

THE COMMITTEE ON RIVERS AND HARBORS,
E. A. HADLEY, *Chairman.*

Appendix A

(1) DEFINITIONS OF TERMS

W. C. Swartout, Chairman, Sub-Committee; W. J. Backes, G. J. Bell, A. F. Blaess, H. A. Dixon, R. E. Fristoe, W. H. Kirkbride, C. U. Smith.

This subject was first presented to the Association at the 1931 convention and was continued on recommendation of the Committee for further study and amplification and to give opportunity to Association members or others for submission of suggestions or criticisms, several of which have been received and considered by the Committee.

The Committee expresses its appreciation of the very hearty interest in our work which has been taken by Professor C. C. Fries, Professor of English, University of Michigan. Professor Fries has given a very considerable amount of time to going over these definitions and working with the Chairman of the Sub-Committee so that they would be correct from the philological standpoint with a view of avoiding confusion on any questions of parallel or synonymous meaning. We are deeply indebted to him for his assistance.

In view of the extensive changes in some of the definitions presented last year and the addition of a number of new definitions in this year's report, the Committee will give further study to the entire subject before asking that the definitions be included in the Manual.

ANCHORAGE.—1. (Marine) Area in which ships are permitted to lie at anchor without interference with traffic or facilities.
2. (Engineering) See Deadman.

APRON.—That portion of a wharf or pier lying adjacent to the waterfront edge.

— TRACK.—Railroad track along the waterfront edge of a wharf or pier for direct transfer of cargo between ship and car. (A.A.P.A.)

— CAR FERRY.—A bridge structure supporting tracks connecting the car deck of a car ferry with the tracks extending to land, hinged at the shore end so that it is free to move vertically at the outboard end to accommodate varying elevations of ferry.

BALLAST, MATTRESS.—See Mattress Ballast.

BANK, CONCAVE.—A curved bank of a river with radius of the curve toward the channel.

— CONVEX.—A curved bank of a river with a radius of the curve away from the channel.

— SLOUGHING.—The caving and sliding of a bank when the material of the bank is unstable due to saturation, undermining or resting on a stratum lubricated by ground water.

BANQUETTE.—Additional embankment or shoulder on land side of levee for the purpose of preventing the line of saturation reaching the surface of the levee slope, also to provide a break in the surface drainage.

BAR.—A shelving elevation of earth or sand which rises considerably above the adjacent area of the bottom of a waterway.

BASIN.—A mooring area for vessels, nearly surrounded by land, usually provided with wharves and sometimes provided with a guard lock to permit the entrance and exit of vessels without fluctuation of water level.

BATTER PILE.—A pile driven at an angle to the vertical for the purpose of resisting lateral thrust.

Batture.—1. That portion of river bank immediately above the foreshore that at times is submerged.

2. That portion of bank between levee and foreshore if levee is in close proximity to river.

Bayou.—1. A sluggish, winding stream in an alluvial terrain.

2. An inlet from a body of water, usually sluggish.

Beach.—1. The shore of a stream or body of water whereon sand, gravel or boulders have been deposited in a fairly uniform inclined plane.

2. That portion of shore that is subject to wash from tide and waves, under ordinary weather conditions.

Bogue.—A mouth; an embouchure; used specifically in the name of the Bogue, the principal mouth of the Canton River, also called Boca Tigris. (See Embogue.) The term applies to mouth or outlet of a river and derives from French or Spanish origin. Does not seem to be used west of the Mississippi River but is used east of the Mississippi River i.e., Bogue Phalia and Bogue Hasty and a few other streams in Alabama and Mississippi.

Breakwater.—A structure built to form or protect a harbor from wave action; also sometimes called mole or jetty.

Brush (For Mattress).—Any live wood growth (preferably willow), main stem one to three inches diameter at butt.

Buckshot.—1. A tough, tenacious earthen material which, when dry, shatters into irregular shaped pieces approximately the size of buckshot or slightly larger.

2. Clay in the form of small balls resulting from the action of water in motion along the bottom of the waterway.

Bulkhead Line.—A line in a harbor defining the channelward limit of solid fills and bulkheads. Such lines are established by the Secretary of War; however, state or municipal authorities under their police powers may establish bulkhead lines shoreward of those established by Secretary of War. (See Pierhead Line.)

Cane.—A hollow, jointed wood stem of the grass family; grown extensively in the South, twenty to thirty feet high. Frequently used in emergencies to construct small revetment where a levee is sloughing.

Cargo Track.—A wharf track to or from which freight is handled from or to boats.

Channel.—1. A navigable passage in a river, lake or harbor, frequently buoyed, dredged and policed.

2. That section of a stream, bay or estuary having the greatest depth and velocity of current—may or may not be the fairway or navigable passage.

Chute.—1. A short, straight channel which by-passes a long bend in a river and formed by the river breaking through a narrow land area between two adjacent bends.

2. A narrow back channel on one side of an island. (Local, used on rivers.)

3. An opening in a river dam for the descent of logs.

Cradle.—A structure riding on an inclined track on the river bank and having a horizontal deck with track thereon for transfer of railroad cars to and from boats at different elevations of water level, generally found on rivers.

— Apron.—Sloping nose on river car ferry which rides under apron girders, forming outer end of a cradle when ferry is landing against cradle. (Used on Mississippi River System.)

— Girders.—Structural members attached to cradle spanning distance between car ferry and cradle. When not resting on cradle apron they ride on a truck which is attached to cradle and which runs on the incline track. (Used on Mississippi River System.)

Crevasse.—A breach in a levee.

Deadman.—An anchorage for a guy, cable, etc., and consists of a timber or piece of structural steel buried in the ground to which is fastened (generally around the middle) the end of the guy line, etc.

Dike.—1. A structure of various materials, usually earth, stone or timber or wire entanglements, erected as a barrier to check, deflect or stop river currents for the purpose of inducing silting and formation of sand bars. (See Jetty.)

2. Sometimes used, especially abroad, as a simile for a levee—a bank to prevent inundations.

— Mud Cell, Brush.—A honeycombed structure with vertical cells 6 to 8 feet square woven with brush and placed against the bank of a river (generally parallel) to build the bank out into the stream, width and length determined by amount of bank to be built out.

— Permeable Pile.—A structure of piling generally normal to the river bank to constrict and throw the channel of a drift bearing sedimentary river. It consists of clusters of piles driven alternately to right and left of a center line with top of clusters about at high water and each cluster bound together and tied to a horizontal pile along the center line about five feet below the top.

— Pile Hurdle.—Same as Permeable Pile.

— Spur.—Any dike extending out from the shore nearly perpendicular thereto.

Dock.—1. A natural or artificial inlet or basin used by boats, including both the water and the protecting sides.

2. A structure against which boats land to discharge cargoes and passengers. Synonymous with wharf and used very generally on Great Lakes.

— Dry.—A structure from which the water may be removed after a vessel enters it and thereafter excluded at will.

Dredge.—A boat or barge with machinery for excavating material at the bottom of a body of water.

— Clam Shell.—Digging element is a bivalve bucket, with or without teeth on cutting edge, operated by ropes from boom of a derrick.

— Dipper.—Digging element is a bottom dumping bucket, mounted on handle, operated from a boom at one end of a barge or scow.

— Grapple.—Digging element is a grab bucket operated by ropes.

— Ladder.—Digging element consists of a series of relatively small, approximately rectangular buckets, mounted on an endless chain, operated into material to be excavated on inclined frame or ladder.

— Orange Peel.—Digging element is bucket with four pointed leaves, operated by ropes from boom of derrick.

— Sea Going Hopper.—A self-propelled hydraulic dredge which dumps excavated material into bottom dump hoppers in its own hull, carrying material to the dumping ground by its own propelling machinery. This type developed for work of ocean bars where it can work when seas would drive other types to shelter.

— Spuds.—Vertical timbers at the corners of the boat or barge or in a well within the hull which, when resting on or driven into the bottom, hold the dredge in place.

— Suction or Hydraulic.—Material to be excavated mixed with water and drawn into a centrifugal pump through an intake pipe and discharged through a pipe.

— Work, Allowable Overdepth.—Excavating to a depth greater than immediately required to make allowance for type of dredge, silting and economy of longer intervals between maintenance dredging.

— Work, Place Measurement.—Excavation measured by sounding before and after removal of material.

— Work, Scow Factor.—Ratio between quantity of material as measured in scows and the quantity as measured in place before excavation. This ratio varies for material, locality and dredging methods.

— Work, Scow Measurement.—Excavation measured by taking number of scow leads and estimated cubic yards in scow.

Embogue.—To discharge itself, as a river, at its mouth. (See Bogue.)

Erosion.—The carrying away of earthen materials by natural processes of water in motion.

Fairway.—That reach of bay or harbor through which shipping passes to and from the sea, and as a general rule buoyed on each hand or having other aids in guiding ships.

Fascine.—Brush bound in a cylindrical bundle from one to three feet in diameter used to protect a river bank.

Fingers.—Inclined supports on a barge on which a mattress is woven and down which it slides to the water as the weaving progresses. (Local, used on rivers.)

Foreshore.—That portion of bank or shore lying adjacent to and sloping gradually to the water.

Freeboard.—The distance between water line and top of levee, dam, embankment or gunwale of a boat.

FURROWED.—Term applied to the levee foundation of natural soil when it has been loosened to minimize seepage or to prevent a levee from sliding on its base; also applied to the surface of an old levee which is to be enlarged.

GROMMET.—In wharf construction, a segmental concrete ring, cast in two parts that overlap to open and close by a spring, and used suspended from a concrete pile jacket. As the jacket is lowered over a pile the grommet at the bottom of the jacket is held close to the pile by a spring and keeps mud from coming up in the jacket—from the nautical term applied to an eyelet of rope.

HARBOR.—A sheltered body of water of sufficient depth to enable a ship to find shelter in it from the storms of the high seas or lakes.

— LINE (INNER AND OUTER).—1. The lines defining the limits of a port or haven with regard to inner or best protected area and outer or less protected area. Often referred to in port regulations.

2. In certain locations of the country inner harbor line is synonymous with bulkhead line and outer harbor line with pierhead line.

IMPERVIOUS EARTH.—Earthen material through which water moves not at all or with extreme difficulty.

JETTY.—An engineering structure at the mouth of a river or harbor or elsewhere, to control the waterflow and currents, to maintain depth of channel, to protect harbor or beach.

LAUNCHING WAYS.—1. (Marine). The guides or track down which a boat or barge is moved after being constructed or repaired in a ship yard.

2. On river work. (See Fingers.)

LEVEE.—An embankment or wall to prevent inundation.

— BACK OF.—Side away from the river, facing the protected area. Sometimes called the land side or inside of levee.

— CORE WALL.—A center wall of selected, impervious material placed in a levee. Used when material within reasonable distance is unsuitable for entire levee.

— CROWN.—Top of levee; is level at right angles to levee center line.

— FRONT OF.—Side next to the river, facing away from the protected area; sometimes called the outside.

— GRADE.—The slope of the crown of levee along the center line.

— HYDRAULIC FILL.—A levee, the material of which is transported and deposited in place by means of water pumped through a pipe line.

— LINE OF SATURATION.—Line across a levee up to which water will theoretically saturate the material. This line slopes down from the water line of river on angle of about 12 degrees to the horizontal in a levee well constructed of good average material.

— MUCK DITCH.—A ditch four to six feet wide and six or more feet deep, excavated in natural soil along the center line of crown of levee to explore foundation conditions where character of material is not fully known or where there is a possibility that water will move between natural surface and bottom of levee. It is backfilled with puddled or tamped impervious material.

— OVERTOPPING.—Applied to a condition when the water reaches a height above the elevation of crown of levee.

— SAND BOIL.—Ebulition of water behind a levee.

— SECTION.—The surface made by a plane cutting the levee perpendicularly to the center line.

— SLOPE.—Amount of inclination of sides of levee downward from the crown. Generally these slopes are one vertical to three horizontal, but occasionally are flatter where less suitable materials are available.

— TOPPING.—Temporary work to raise elevation of crown of levee. Done only when there is danger of overtopping.

— WAVE WASH.—Erosion of the levee caused by waves across large areas of water during flood periods.

MATTRESS.—A strong mat consisting of various materials, bound or woven together, used for the protection of the surface of the eroding banks or bottom of an alluvial river.

— BALLAST.—Stone riprap placed on any wood mattress to sink it and make it conform to the river bed.

— BASKET WOVEN.—Brush (preferably willow) woven similar to a chip basket with selvage of roll fascine bound to mattress by wires.

— BOARD.—Mattress woven with boards, alternately headers and stretchers.
— BRUSH AND WEAVING POLE.—Brush with poles on top and bottom tied together with wires. Brush laid normal to river bank with poles parallel.
— BRUSH AND WIRE ENVELOP.—Brush laid in two layers between woven wire netting, which is tied together with wires. Bottom of netting envelop parallel to bank, top normal to bank. Bottom brush layer normal to bank, top parallel.
— BRUSH, POLE AND FASCINE.—Brush fascines with poles on top and bottom tied together with wires. Fascine laid normal to river bank with poles parallel.
— CONCRETE, ARTICULATED.—Mattress of connected reinforced concrete slabs.
— CONCRETE SLAB.—A reinforced concrete mat or pavement laid on the bank or bottom of an alluvial river for the purpose of preventing erosion. Mattresses of this type are usually poured in place.

PERVIOUS STRATIFICATION.—A layer of varying degrees of permeability composed of boulders or gravel extending across a levee or fill.

PIER.—1. A vertical support of an engineering structure.
2. A structure at an angle with the shore line of a body of water, providing docking space on both sides for vessels to receive and discharge cargo, passengers and supplies.
— FENDER.—Any construction adjacent to a wharf, pier, slipwall or other structure to prevent contact and damage to vessel or structure.
— HEAD LINE.—A line in a harbor defining the channelward limit of structures. Such lines are established by the Secretary of War; however, state and municipal authorities, under their police powers, may establish pierhead lines shoreward of those established by Secretary of War. (See Bulkhead Line.)

POROUS OR PERVIOUS EARTH.—Earthen material through which water moves quickly and readily.

PORT.—A harbor plus terminal facilities.

QUAY.—A structure provided with facilities on one side for vessels to load and discharge cargo, passengers and supplies.

REEF.—A narrow ridge of rock, earth or sand lying slightly below or above the surface of the water.

RETARDS, CURRENT.—Wire entanglements or full size trees laid parallel and bound together at the trunk end by cables, so placed in a river as to catch drift and thus check the current, causing silting. The shore end of a current retard is anchored to the bank midway of a mattress about 300 feet long, with retard normal to bank and extending in the stream any desired length. Retard in stream is anchored to patented concrete piles sunk below river bed by jetting and driving.

RIPRAP.—Pieces of stone, approximately cubical shape, placed along a bank or around a structure to secure protection from erosion or scour.

RIVER WATER GAGE.—A gage graduated in feet and tenths to show elevation of water surface, generally with zero of gage below extreme low water and extending above extreme high water.

SEA LEVEL, MEAN.—The average height of the sea between high and low tides. It is determined by averaging the hourly heights of the tide for a considerable period of time and is established by the U. S. Coast & Geodetic Survey.

SEAWALL.—A barrier along the shore line to prevent encroachment of the sea by direct wave action.

SEDIMENT.—Earthen material carried in suspension by a stream or deposited upon its bed.

SEEPAGE—Water passing through or under a levee or dam from the higher to lower side.

SEEP WATER.—Water which has passed through or under a levee or dam.

SHOAL.—A shallow place in any body of water, detached from the shore.

SILTING.—The depositing of suspended material carried by a stream when weight of such suspended material is in excess of the sedimentary transporting power of the current.

SLIP.—1. Open waterway or tidal dock between piers.
2. A water space protected by racks on each side and sufficient only for the accommodation of one vessel. Usually used in referring to ferries.

SOUNDINGS.—Measurements of the depth of water, giving elevation of under water land surfaces.

SPUD.—(See Dredge Spud.)

TERMINAL.—A terminal is the end of a movement in transportation.

THALWEG.—(From German.) The line following the deepest part of the bed or channel of a river. Originally, this word meant the line in the bottom of a valley in which the slopes of the two sides meet and which forms a natural water course.

TIDE LEVEL, MEAN.—(See Sea Level.)

TOWHEAD.—A bar covered with grassy growth of young willows and other vegetation. (Local, used on Mississippi River System.)

WALING PIECE.—1. A timber on the water side of a pier, wharf or quay to prevent damage, by a vessel, to the main structure by a vessel.

2. Timber used as a guide or brace in construction work.

WAVE WASH.—(See Levee Wave Wash.)

WHARF.—A berthing place for vessels to load and discharge cargo, passengers and supplies. Piers and quays are distinctive forms of wharves.

Appendix B

(2) RECOMMEND SUITABLE TYPES OF CONSTRUCTION FOR LEVEES, DIKES AND MATTRESSES FOR USE UNDER VARYING SERVICE CONDITIONS, GIVING CONSIDERATION TO STREAM ALINEMENT, SUB-SURFACE, SOIL OR OTHER LOCAL CONDITIONS

A. F. Blaess, Chairman, Sub-Committee; G. J. Bell, E. A. Craft, A. F. Crowder, H. A. Dixon, B. Elkind, F. G. Jonah, C. E. Weaver.

The problems of flood control and protection as covered by the work of this Committee may be grouped under three general classifications, namely: (1) Construction of levees; (2) Bank protection for the prevention of sloughing, caving and erosion; (3) Channel stabilization.

In the generally accepted sense of the term, levees are earthen embankments designed to prevent the inundation of any area subject to overflow although they are also sometimes constructed of masonry, loose rock filled with earth, timber, concrete and of steel sheet piling. The great majority of levees, however, are constructed either of earth or of concrete, the use of concrete being confined almost entirely to congested areas where there would not be sufficient room for the construction of earthen levees of the proper design.

There are various forms of protection work in use, the most common being the continuous or revetment type consisting of mattress and paving, and the intermittent type consisting of dikes or retards placed at intervals along the bank to be protected. The type of revetment to be used is usually governed by local conditions and is also dependent on the material available at or near site of work.

The mattress used in the construction of the continuous type of revetment may be covered under three general classifications, namely, the willow or brush mattress, the timber or board mattress, and the concrete mattress.

The use of a mattress of any type is designed to protect an area exposed to scour and resultant caving or sloughing of the banks. The method of construction varies to a great extent in different parts of the country, as for example on the upper reaches of the Mississippi River where the heavy fascine type of mattress is used, the lower delta of the Mississippi where on account of the deep water the framed type of brush mattress is used and on the Missouri River where the basket weave type of mattress is used. The availability of material for the construction of mattresses is also a factor influencing its design, the board mattress being used in many instances where brush is not avail-

able. The brush mattresses formerly used so extensively on the Mississippi River are being largely replaced by slab concrete revetment and articulated concrete mattresses due to the scarcity of willows and the greater economy in the construction of concrete mattresses on a large scale.

A typical board mattress is constructed of 1 in. by 6 in. yellow pine lumber spaced 1 inch between edges of board and woven on 1 ft. by 6 in. binders although the dimension of timber and method of construction varies somewhat in different territories. The board mattress is desirable where the scarcity of brush requires the use of this type of mattress. It is not as desirable as brush mattress, particularly in sand or on rivers with high velocities, as it is not effective on sandy banks and the light construction will not withstand heavy attacks of river currents.

Brush or willow mattresses are of three general types, the woven, the framed and the fascine mattress. The woven willow or brush mattress consists of brush poles and cables woven together to form a continuous mat. The framed mattress consists of willow or other brush tightly compressed between two timber grillages. The fascine mattress consists of bundles from 12 to 18 inches in diameter of willow or other brush placed side by side and tied together by cable or wire to form a continuous mat.

Continuous concrete slab pavement is usually composed of slabs cast in sections 6 inches thick and to the width and length desired. Articulated concrete blocks for pavement vary in dimension from 12 inches square to 3 ft. 11 in. long by 11½ in. wide, the latter being the dimensions used by the Mississippi River Commission. These slabs are fastened together by wire mesh or cable.

The size of the mattress also varies according to the type of mattress and the area to be protected. For example, the heavy fascine mattress as used on the Mississippi River is from 100 ft. to 300 ft. wide and from 1000 ft. to 1200 ft. long. The framed brush mattress is usually constructed in sections 100 ft. by 150 ft., while a standard basket mattress as used on the Mississippi River is 86 ft. wide and constructed to any desired length. The ordinary requirements for railroad bank protection as a rule do not call for such extensive mattresses as used on the Mississippi and other large rivers.

Except in special cases railroad bank protection does not require the installation of a heavy mattress such as used on the Mississippi River, for ordinary conditions the basket weave or loose fascine type mattress being adaptable, and if the scarcity of material does not permit the use of a brush mattress a board mattress should be used.

Specifications as submitted herewith for a woven willow mattress appear to be well adapted for local conditions such as are ordinarily found in railroad work.

Other types of protection designed to prevent erosion of banks and for channel stabilization are what may be classified as the intermittent type as distinguished from continuous revetment or mattresses. This form of protection is designed in some instances to slow up the velocity of water at a fixed point, thus causing the suspended matter carried by the water to drop out and form a deposit or for the purpose of diverting or training the current in such a way as to stabilize the channel.

Flood protection of the intermittent type is of many different forms but can be summed up under the general classification of retards and may be constructed of piling either in a continuous row or alternate clusters of two, three or four piles with horizontal piles tied to the clusters; of steel, wire entanglement designed to collect silt and form bars; of alternate layers of pole or brush placed or anchored to position in a desired location, of bundles of brush (fascines) tied firmly with wire or cable either with or without riprap core and anchored to position, or in fact any material that will remain in position and retard the flow of water to the extent that deposits will form.

The Erie Railroad has successfully developed a rather unusual method of controlling the erosion on two small rivers near Hornell, N. Y. A great deal of trouble has been experienced through the erosion of gravel on the steeper sections of the river up-stream from the railroad. This gravel was deposited in the flatter and more crooked sections of the river immediately down-stream from the railroad and under the railroad bridges.

The method followed was the construction of dams and control spillways. The principle underlying the scheme was simply the reduction of velocity where erosion occurred and the provision of an adequate channel to take care of the maximum flood discharge through spillways.

(3) SUBMIT SPECIFICATIONS FOR THE CONSTRUCTION OF THE SEVERAL TYPES OF RIVER BANK PROTECTION IN COMMON USE

The following specifications covering hydraulic methods of levee construction are taken from the standard specifications for levee work of the Engineering Department, U. S. Army, and are submitted, herewith, as additions to the specifications for levee construction appearing on page 1346 of Bulletin 324.

HYDRAULIC METHODS.—A Contractor proposing to do the work hydraulically will be required to comply with the following:

In placing the material for levees hydraulically, slopes shall be made continuous and away from the existing levee on enlargement work, or away from the center line on new levee.

Unless otherwise authorized in writing by the Engineer, free outlets for waste water shall be provided at intervals of not more than 1000 feet for 12-inch dredges or smaller; 1500 feet for 13 inch to 16 inch dredges; and 2000 feet for dredges over 16 inches. No obstruction to free flow will be permitted in these outlets or at any points in the levee embankment, except that a transverse retaining dike shall be constructed immediately below each outlet; and shall not be breached until the end of the discharge pipe has approached the retaining dike to within 250 feet in the case of 12 inch dredge or smaller; 375 feet in the case of 13 inch to 16 inch dredges; or 500 feet in the case of dredges over 16 inches.

The Contractor shall take necessary precautions to prevent damage from waste water or other causes, and shall hold the railroad harmless against any and all claims for damage occasioned by his operations.

Preparation of foundation as required shall be kept far enough in advance of construction to permit thorough inspection prior to flooding. When fill is deposited in old pits for subsequent rehandling, the pits shall, prior to flooding, be cleared of all trees, logs, driftwood, and debris beyond the outer limits of reexcavation.

The Contractor may, at his option, utilize pits other than those furnished by the railroad, provided he obtains right of way thereto and property rights to the material therein, and that the location and dimensions of pits, and the character of material therein as indicated by borings submitted by the Contractor, be approved by the Engineer.

Should the material encountered in pits other than those provided by the railroad require the use of a levee section larger than that estimated in the spcifications, the larger section must be built without added compensation, or the pits originally designated by the Engineer must be used.

No payment will be made for material wasted by reason of the above requirements pertaining to hydraulic work.

Bidders proposing to do any work by hydraulic method shall submit to the Engineer for approval sketches and description of the plan proposed to be followed and shall indicate provisions for drainage. The plan shall include location and depth of borrow pits, if other than those indicated therewith, with borings of same. All of these plans when approved by the Engineer will become a part of the contract, if contract is made. Approval of location and depth of such proposed pits shall not relieve the Contractor from the obligation to furnish satisfactory material nor in any way commit the Engineer to acceptance of unsatisfactory material or to responsibility for the character, quantity or procurability of material from pits whose location is thus approved but which are not furnished by the railroad.

Should the hydraulic construction result in the separation and elimination of any ingredients of the soil as originally found in the pits to such a degree as to change its classification to one requiring a larger levee section than that prescribed for the material as found in the pits, and estimated in the specifications, the larger section shall be built without additional cost to the railroad. The additional yardage so required will not be considered as forming a part of the allowable excess.

The specifications for net cross-section of levees with and without banquette which follow, are also taken from the standard specifications of the Engineering Department, U.S. Army, and are submitted as a part of the specifications for levee construction appearing on page 1346, Bulletin No. 324, replacing the paragraph on levee section appearing on page 1348 of Bulletin No. 324:

Net Cross-Section Levees Without Banquette.—Unless otherwise specified levees on the Mississippi River below the mouth of the Ohio shall be constructed to the following net dimensions:

Section	*Crown (feet)*	*Riverside Slope*	*Landside Slope to contain seepage line of*	*Governing Material*
A	10	1 on 3	1 on 6	75% or more buckshot
B	10	1 on 3½	1 on 6½	Loam
C	12	1 on 5	1 on 8	75% or more of sand

The landside slope of levees shall extend in a straight line from the crown elevation to a point where the seepage line intersects the surface of the ground.

Note.—The seepage line springs from the riverside slope, at the elevation of the assumed maximum flow line. In the cases of protection levees not a part of the Mississippi or Atchafalaya River systems, the term "landside" as used in these specifications is to be interpreted as referring to the side facing the area being protected.

Levees With Banquette Above the Mouth of the Ohio River.—Crown to be 8 feet wide—reduced to 6 feet above mouth of Missouri River; riverside slope to be 1 on 3; and landside slope to be 1 on 3 to intersection with top of banquette, which shall be from 5 to 8 feet below the levee crown, and shall have the following dimensions: top to be 30 feet wide for levees from 13 to 16 feet high, and 40 feet wide for levees exceeding 16 feet in height; top to have slope of 1 on 10 away from the levee; and rear slope to be 1 on 4 to intersection with natural ground. No banquette will be required on levees less than 13 feet high, in which case landside slope shall be 1 on 3 to natural ground surface.

The work shall conform to the maps, profiles, typical cross-sections, and/or other drawings which form a part of these specifications.

These levee sections are in accordance with Engineering Department, U.S. Army specifications for levees on the Mississippi River. For tributaries of the Mississippi or other rivers the Engineer shall decide as to the section at any location.

SPECIFICATIONS FOR WOVEN WILLOW MATTRESS

Mattress

The general design and construction of the mattress shall consist of a continuous woven willow mattress 12 inches thick and 80 feet, more or less, wide. Mattress shall be sunk to the bed of the river and parallel with the shore, the inside edge being located as may be directed by the Engineer.

Mattress shall be woven with selvedge edge, using straight, live willow brush of approximately 2½ inches thickness at the butt and preferably of approximately 15 foot length. Same shall be woven by skilled weavers and weaving shall begin at a point at upstream end and widen as rapidly as possible to full 80 foot width as the weaving progresses downstream.

Mattress shall be fastened together and anchored with ⅜ inch galvanized wire cables. These cables shall be laid under the mattress longitudinally and transversely at intervals of 10 feet. The first four longitudinal cables on outer side shall be doubled, and shall be securely fastened at selvedge edge of mattress and at each intersection of cables, this to be accomplished by pulling cable through mattress and fastening with 4 inch hardwood pole not less than 12 feet long. As weaving progresses the longitudinal cables shall be secured to deadmen on the shore 150 to 200 feet above mat as directed by the Engineer.

Sinking Mattress

Outer edge of mattress shall be weighted with rock of 40 to 50 pounds weight, securely wired to the mattress to insure the sinking of same. Sufficient rock shall be placed on upper end of mattress to hold it in place while remainder of mattress is being sunk. The quantity of rock to be placed on mattress shall be 1.8 cubic yards, more or less, for each 100 square feet of mattress as directed by the Engineer, this rock to be uniformly distributed over the top of the mattress.

Bank Grading and Paving

The bank above the mattress shall be cut to a uniform slope as directed by the Engineer, and shall be covered with one-man size riprap, placed by hand to a uniform depth of ten inches. All spalls shall be placed on top of bank paving.

Snags, Etc.

Snags, logs or other obstructions in bed of stream that would prevent mattress from resting uniformly on the bottom or would interfere with anchorage on shore shall be removed by the Contractor at his expense.

General

The Contractor shall submit a unit price per square of mattress in place, which price shall include the furnishing of all materials, except rock, the hauling of all materials, and the sinking of mattress and placing of the specified quantity of rock thereon.

All materials furnished and all work done shall be of the best obtainable characteı and shall be acceptable to the Engineer. Should any material be furnished or work done that in the opinion of the Engineer does not conform to the letter and spirit of these specifications, the Engineer may reject the same, and the Contractor shall promptly replace any material so rejected or reconstruct or repair any work not acceptable.

SPECIFICATIONS FOR POLE AND BRUSH BANK MATTRESS

The general design of the mattress shall consist of a pole framework upon which is placed willow brush, with a pole framework laid on the top.

Mattress

The framework shall be made of native poles 24 feet in length, the longitudinal poles being spaced 5 feet 3 inches apart and the transverse poles 24 feet long, spaced 8 feet apart. The longitudinal poles shall lap at least four feet and the whole framework shall be securely fastened together with No. 9 galvanized wire.

Upon this pole framework shall be laid willow brush in bundles of about the size used in weaving a willow mattress. The first course of brush shall be laid transversely with butts toward outer edge, to a width of 24 feet. The second course shall be laid lengthwise, with the butts upstream, and the third course transversely the same as the first course. When all brush is in place, a pole framework the same as that on the bottom shall be placed and securely fastened in place by wiring to the lower frame.

The mattress shall be anchored to the bank with ⅜ inch seven strand wire cable as required by the Engineer.

Sufficient brush shall be used in mattress so that when covered with riprap the mattress shall be not less than 12 inches thick.

Sinking Mattress

Upon the mattress described shall be placed sufficient one-man size riprap to sink the mattress and hold it securely in position, the quantity to be as directed by the Engineer.

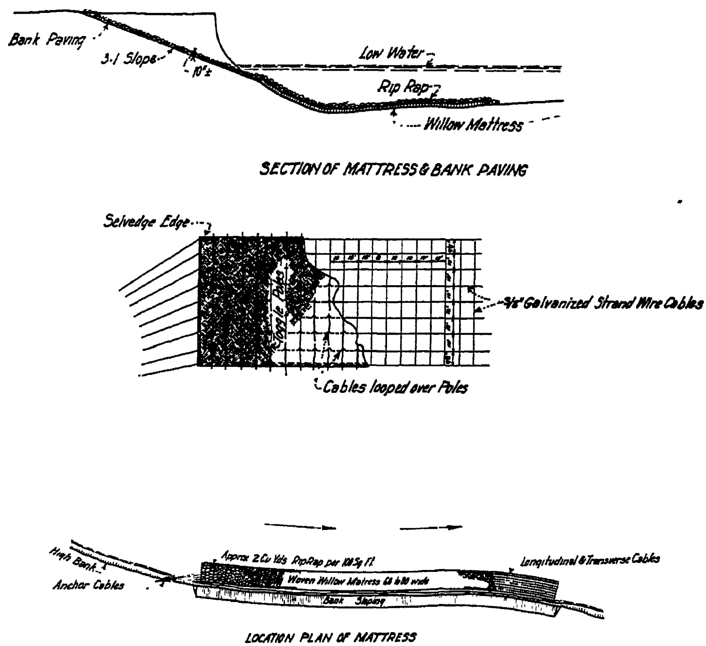
Bank Grading and Paving

The bank above the mattress shall be cut to a uniform slope as directed by the Engineer, and shall be covered with one-man size riprap, placed by hand to a uniform depth of ten inches. All spalls shall be placed on top of bank paving.

General

The Contractor shall submit a unit price per square of mattress in place, which price shall include the furnishing of all material, except riprap, the hauling of all materials, the sinking of mattress and placing of the specified quantity of rock thereon.

All materials furnished and all work done shall be of the best obtainable character and shall be acceptable to the Engineer. Should any material be furnished or work done that in the opinion of the Engineer does not conform to the letter and spirit of these specifications, the Engineer may reject the same, and the Contractor shall promptly replace any material so rejected or reconstruct or repair any work not acceptable.



SKETCH NO. 1—WOVEN WILLOW MATTRESS

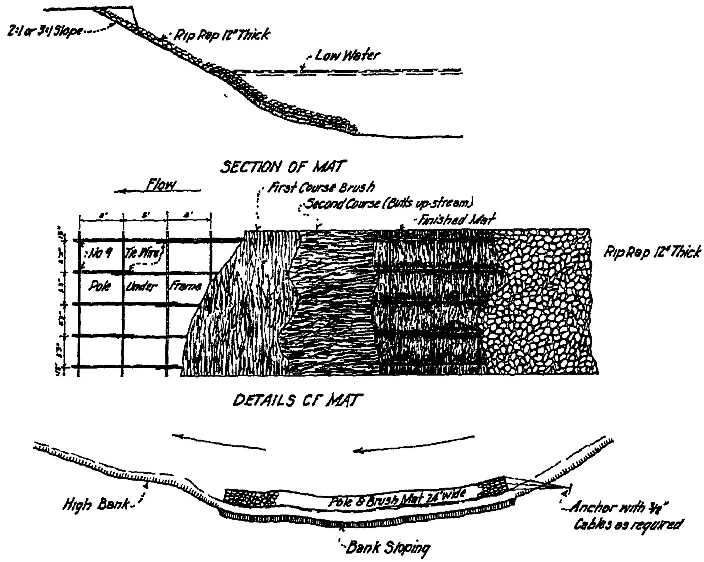
SPECIFICATIONS FOR POLE BRUSH AND ROCK DIKES

The general design of dikes shall consist of a pole and brush mat upon which is placed one-man sized riprap to the width, slope and height specified herein.

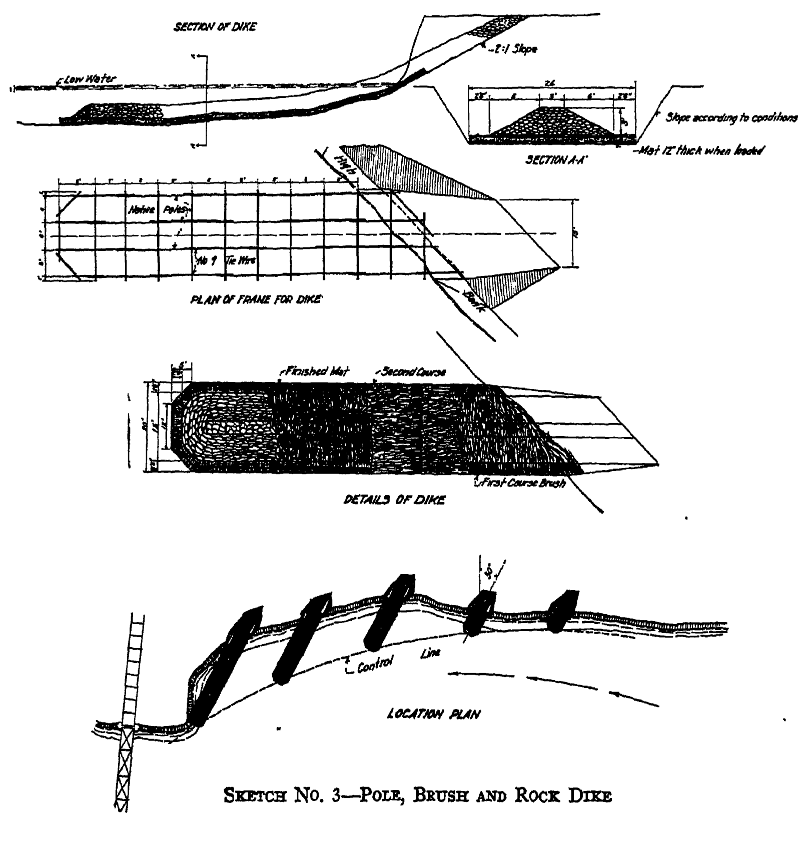
Mat

The mat shall consist of brush placed in small bundles upon a pole framework. Mat shall begin at a point on the bank approximately five feet above low water and where the bank is steep the mat and dike shall be placed in trench having a slope of two feet horizontal to one foot vertical.

The frame shall be made of sound straight native poles of suitable length, the longitudinal poles to be spaced six feet apart and transverse poles eight feet apart. The longitudinal poles shall be lapped at least four feet and the whole framework shall be securely fastened together with No. 9 galvanized wire. Upon the frame shall be laid straight live willow brush in small bundles with butts on the outer edge, the first course to be laid transversely to a width of 20 feet. The second course shall be laid lengthwise with butts toward the shore and the third course shall be laid transversely the same as the first, and upon the same shall be placed a pole frame the same as that on the bottom, same to be securely fastened in place by wiring through the bottom frame.



SKETCH NO. 2—POLE AND BRUSH BANK MAT



SKETCH NO. 3—POLE, BRUSH AND ROCK DIKE

Riprap

Upon the completed mat shall be placed one-man sized riprap, as nearly as possible, to a height of 3 feet, with a base width of 15 feet, and top width 3 feet. So far as possible this riprap should be hand laid and as much of it as possible placed on the mat before it sinks. The rock portion of dike shall extend above the mat to top of high bank. Where the bank is steep trench shall be excavated from low-water level to top of bank on a slope of 2 feet horizontal to 1 foot vertical for the full width of rock portion of dike. After the bank portion of rock dikes is in place, trenches shall be backfilled with earth or riprap as directed by the Engineer.

Brush

Brush used in mat shall be straight live willow brush of approximately 2½ inches thickness at the butts and approximately 15 feet in length. Brush shall be laid in bundles or sheaves of approximately the size used in weaving a willow mattress.

Snags, Etc.

Snags, logs or other obstructions in bed of river, that would prevent the dikes from resting uniformly on the bottom, shall be removed by the Contractor at his expense.

General

Contractor shall submit a unit price per square for pole and brush mat in place, and a separate unit price per cubic yard for placing riprap on the mat. These prices shall include the furnishing of all materials, except riprap, and the hauling and placing of all materials.

All material furnished and all work done shall be of the best obtainable character, and shall be acceptable to the Engineer. Should any material be furnished or work done that in the opinion of the Engineer does not conform to the letter and spirit of these specifications, he may reject same and the Contractor shall promptly replace any material so rejected or reconstruct or repair any work not acceptable.

SPECIFICATIONS FOR BRUSH FASCINES

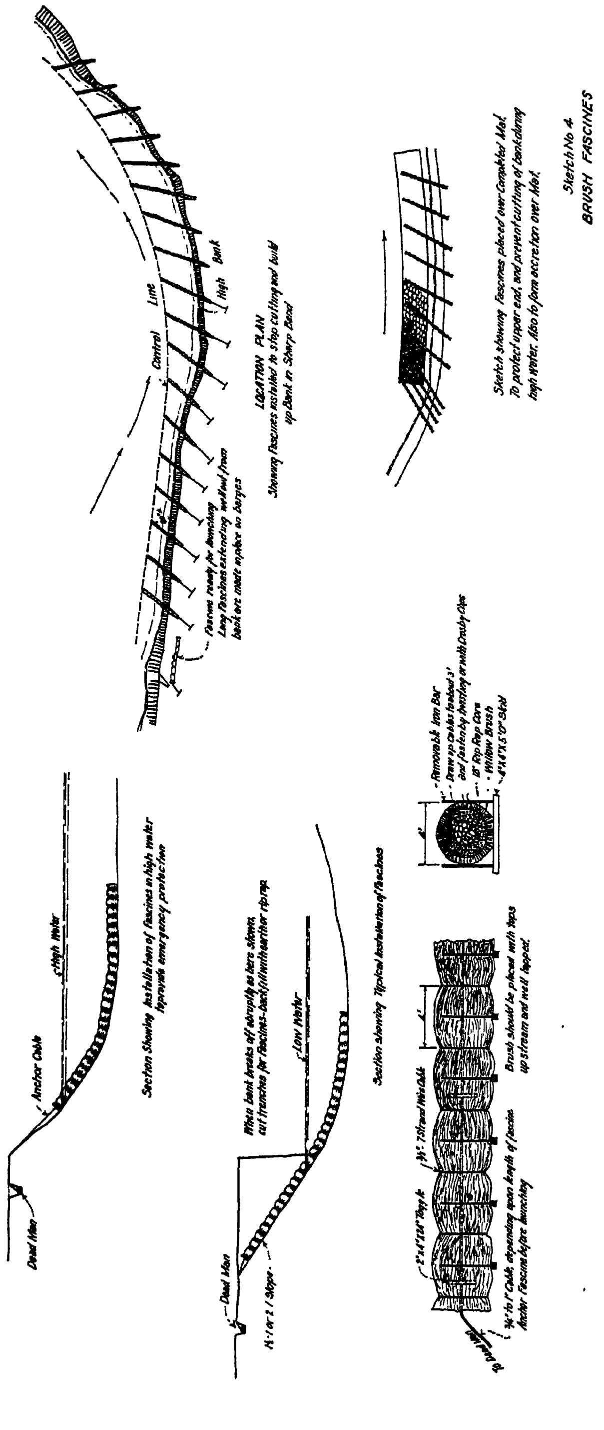
The fascines shall be made as nearly as possible 3 feet in diameter when finished and shall have a riprap core of 18 inches. The anchorage cable shall be of ⅜ inch galvanized strand wire cable, and shall extend entirely through the length of fascine, same to be doubled when so directed by the Engineer, and shall be secured by toggles at intervals of 12 feet. Fascines shall be anchored to deadmen located on shore as directed by the Engineer.

Fascines shall be drawn up and bound with ⅜ inch galvanized strand wire cables, spaced approximately 4 feet apart. Brush should be placed in fascines with tops toward the deadmen on the shore.

When required by the Engineer, the shore end of fascines shall be placed in a trench, same to be cut to a base width of four feet and to such slopes as directed by the Engineer. Fascines shall be carried to within 2 feet of top of high bank and when same is in place the trench shall be backfilled as directed by the Engineer.

General

The Contractor shall quote a unit price per linear foot of fascines in place, this price to include the furnishing of all materials except riprap, and the hauling of all materials.


Control Line
High Bank
Fascines ready for launching. Long Fascines extending well out from bank are made in place on barges
LOCATION PLAN
Showing Fascines installed to stop cutting and build up Bank in Sharp Bend
Sketch showing Fascines placed over Completed Mat. To protect upper end, and prevent cutting of bank during high water. Also to form accretion over Mat.
Sketch No 4
BRUSH FASCINES
Dead Man
Anchor Cable
High Water
Section Showing Installation of fascines in high water for rapid emergency protection
Dead Man
1½:1 or 2:1 Slope
Low Water
When bank breaks off abruptly as here shown, cut trenches for fascines-backfill with earth or riprap.
Section showing Typical Installation of Fascines
Removable Iron Bar
Draw up Cables to about 3' and fasten by twisting or with Crosby Clips
18" Rip Rap Core
Willow Brush
4"x4"x5'0" Skid
4'
2"x4"x24" Toggle
¾": 7 Strand Wire Cable
Brush should be placed with tops up stream and well lapped.
¾" to 1" Cable, depending upon length of fascine. Anchor Fascines before launching
To Dead Man

Said price shall also include the furnishing of all tools and equipment, including barges, launching ways, etc.

All material furnished and all work done shall be of the best obtainable character, and shall be acceptable to the Engineer. Should any material be furnished or work done that in the opinion of the Engineer does not conform to the letter and spirit of these specifications, he may reject same and the Contractor shall promptly replace any material so rejected or reconstruct or repair any work not acceptable.

Appendix C

(4) DESCRIBE DIFFERENT TYPES OF BULKHEADS, JETTIES AND SEAWALLS, GIVING CROSS-SECTIONS OF EACH AND STATING THE PURPOSE WHICH THEY SERVE, INCLUDING COMPARISONS OF FIRST COST, SERVICE LIFE AND MAINTENANCE COST OF THE VARIOUS TYPES

R. E. Fristoe, Chairman, Sub-Committee; W. L. Morse, W. J. Backes, R. J. Middleton, G. A. Rodman, E. H. Roth, W. C. Swartout, W. G. Brown.

The report is confined to structures in harbors except that in the case of seawalls some designs have been included of walls along the ocean shore where the wave action is much more severe than in most harbors.

Bulkheads

Bulkheads vary in design depending on the depth to satisfactory foundation and the character of the material to be confined.

Temporary bulkheads constructed of timber, without rock reinforcement, may be made to take the place of a rock fill or of a masonry or concrete retaining wall.

Generally, in temporary construction, two pile bents are driven, on ten feet centers with the piles on ten feet centers in the bents. Longitudinal braces are placed between bents on both sides of the trestle at the top and at low water. A horizontal girt and sway bracing are then placed and a batter pile driven to give additional stiffening. When a middle waling piece has been placed on the fill side of the trestle half way between the top and bottom longitudinal braces the sheet piling is driven with these timbers as backing and three waling pieces are then placed on the fill side of the sheet piling and bolted through to the bracing and middle waling piece behind to hold the sheet piling in place.

The ten-foot spacing of the bents and piling is very convenient as a single line of 12 in. $\times$ 12 in. stringers on each side will carry the usual track structure and loading, in case it is found desirable to dump rock from the trestle to reinforce the sheet piling in holding the fill.

A temporary bulkhead of this type may be used to hold a hydraulic fill. In this case it is often desirable to drive the sheet piling on the outside face of the trestle so that the trestle construction is included in the filled area. Rock and gravel can be dumped through the trestle to give it stability the same as before and if the fill is on mud bottom or deep enough to require it, rock and gravel can be placed on the outside of the sheet piling.

For temporary bulkheads, second-hand trestle stringers make very satisfactory sheet piling and can be made watertight by spiking 6 in. $\times$ 6 in. pieces to the edges of the stringers to get a tongue and groove effect. The 6 in. $\times$ 6 in. pieces should be beveled

at the mill so that when spiked to the stringers the bottom of the groove and the face of the tongue will be wider than the top of the groove. Then when the driver lifts a stringer and sets it in position to drive, the tongue and groove key together and the stringer follows down in line.

Temporary structures of this type should have no maintenance cost. Their life is the life of untreated timber but is usually sufficient for a mud-fill to harden. If the temporary bulkhead is used as the center membrane of a sea-wall the life is sufficient to give time for the placing of the more permanent construction.

Plate I shows a design for a permanent bulkhead in comparatively shallow water where creosoted piling and creosoted timber are used with three pile bents and the sheet piling placed on the fill side of the trestle. The mud pressure on the bulkhead is balanced up with a rock fill of riprap on the outside and on account of using a three pile bent a 4×8 swaybrace bolted to the inside end of the cap gives sufficient stiffness. The two outside piles are spaced conveniently for track stringers and the resulting structure will accommodate a permanent track at the outside edge of the fill.

For bulkheads of moderate height many combinations of timber and rock are used, varying from watertight sheet piling to occasional piling and large rock used to hold comparatively stable earth embankment.

All bulkheads when made permanent are finished in riprap, stone or concrete. Where concrete bulkheads will be exposed to seawater, care should be taken to see that the concrete is proportioned in such a way as to secure maximum density and is mixed thoroughly to secure concrete upon which the sea will have but little effect. When concrete is given time to harden before exposure to sea water, little difficulty from deterioration due to sea water is experienced. In some cases precast reinforced concrete slabs have successfully been used to face bulkheads, mass concrete being placed behind them.

Permanent bulkheads of the type shown in Plate I are considered to have no maintenance cost. The maintenance of the track structure cannot be charged to the bulkhead. The life of the creosoted timber will be from 20 to 40 years according to how carefully the joints have been protected and when the timber has outlived its usefulness the rock should form a permanent bulkhead.

The use of creosoted timber is governed by the desired life of the track structure or perhaps by an unusually rapid deterioration of untreated timber from some cause such as marine borers or termites.

Jetties

Jetties placed as harbor structures are in most cases permanent structures of rock or concrete combined with sand, where the sand is plentiful, and in some cases treated timber reinforced with rock fill.

The alignment of jetties and training walls with respect to tidal currents and prevailing storms will not be here considered, as this is believed to be mainly determined by a special study at each location. Also the question as to the necessity of constructing single or double jetties at the entrance of tidal rivers for the purpose of keeping a channel open across bars is believed to be a problem that must be worked out for each case on its merits.

Where sand is plentiful and the currents will permit, a sand fill may be made and later blanketed with rock.

The Mare Island Strait is the stretch of water at the mouth of the Napa River on the upper end of San Francisco Bay, where the waters of the Napa River flow into the Carquinez Strait from the north at about right angles to the tidal currents, while the

waters of the Sacramento and San Joaquin Rivers which are heavily laden with silt flow into the Carquinez Strait from the east. The currents of the Carquinez Strait flow by the mouth of the Mare Island Strait with varying intensity depending on the direction of the tide and the volume of water coming in from the combined flow of the Sacramento and San Joaquin Rivers.

The U.S. Navy Yard is located on the Mare Island Strait and to prevent the tidal currents from carrying silt into the Navy Yard basin on the flood tide and river currents from carrying in silt on the ebb tide, the Government has placed two single lines of jetty. One jetty is at right angles to the flood tide as it would turn north to enter the Navy Yard from the west and the other is at right angles to the river currents as they would enter the Navy Yard from the east. The fairway between the ends of the jetties is less than one-quarter of a mile and the current here is sufficient to maintain a depth of 5¾ fathoms at mean lower low water. Jetties are also used to quiet the water and promote desired silting.

Jetties of the Mare Island type are constructed by building a timber bulkhead and reinforcing it with rock to prevent the current from working between the timber or underneath. Permanency comes from the silting up of the rock and bulkhead which results from the slowing up of the currents heavily laden with sediment.

The efficiency of the jetty described is indicated by shallow water of a fathom or less on the bay side and deep water of about six fathoms on the inside of Mare Island Strait.

Jetties are considered as permanently located structures, any timber used being reinforced with permanent material during the life of the timber.

Seawalls

Seawalls installed as harbor structures vary from dumped rock to timber and concrete construction but are very similar to bulkheads in land locked harbors where the wave wash is of small magnitude.

In harbors or open roadsteads where seawalls are necessary for protection from the action of breakers and heavy storms, the seawall design must be developed to absorb the pounding from a heavy surf.

Plate II shows five types of sea walls which have been installed along the California coast during the last twenty-one years and which would be appropriate for consideration as a harbor structure where surf was experienced. The table shows the dates and locations at which the different types of wall have been constructed, as also the lengths and cost per linear foot.

Certain requirements must be kept in mind in connection with sea walls. A sea wall must be built on rock foundation when possible. Seawalls have shifted and broken where the foundation has been carried four or five feet down into a hard sand shore. Channel and tidal currents change and seawalls not built on rock have at times been undercut, requiring extensive repairs.

A seawall should be placed far enough out from the shore it protects to receive the force of the waves and prevent any pounding effect from the water which may go over it. The exception to this rule is Type "E" on Plate II, which is not so much a seawall as a concrete facing to protect the shore rock from the pounding of the waves.

Under heavy wave action, the beach sands move and if bedrock is not present, riprap is usually the best protection. Riprap will, however, gradually work into the sand and requires maintenance to keep it up to grade. Pile foundations are seldom used due to cost and the hazard of under-cutting.

Type "A," the square section, is perhaps the best design of concrete section where rock foundation is not present and riprap is too expensive. With this section, if the bottom is undercut by wave and current action and the wall is rolled over, the new face presents practically the same resistance to the wave action as the original face.

Type "B" is designed to turn the waves up and back without the impact of a direct blow and should in all cases have a rock foundation or construction that will insure against overturning. The face of the wall has a one to one batter ending in the throw-back curve which turns the wave back on itself so that all force of the breaker is expended and the water carried over the wall is only wind blown spray.

Type "C" is a modification of Type "B" which may be used under certain conditions where the foundation and backing are such that the height may be safely made greater than the width of the foundation.

Type "D", which has been recently developed, is an improvement on Types "B" and "C" in that the top is sloped to secure better drainage and the bottom has rail anchorage as shown, giving greater stability against overturning.

All of the above sea walls should not only be set out from the shore where they will absorb the force of the breakers, but should be filled in behind with hard field stone, beach cobbles, or other water washed material that will form a beach gently sloping up from the top of the wall and on which spray may land and run off without causing erosion.

Type "E", listed as "Toe Protection", generally costs about one-sixth as much as a seawall and can be used as a concrete slab to face soft rock which is rapidly being disintegrated by the waves and weather. The three feet six inches shown at base must be increased where necessary to carry the bottom into the rock. The top must be carried above wave action and carefully let into the rock to prevent cutting out behind the concrete. Rim rock protection or "Toe Protection" according to the design of Type "E" requires yearly maintenance to keep it in good condition the same as riprap. In fact the concrete faces of the sea walls themselves show wear from the pounding of the waves which amounts to approximately an inch over a period of ten years and has been of sufficient extent in places to justify plans for building up the face.

Where it is found necessary to place a concrete seawall on pile foundation, sheet piling, either steel or wood, is driven under the front edge of the seawall outside of the foundation piling. If the beach is not too gravelly, three by twelve untreated planks may be spiked together in three thicknesses to give a tongue and groove effect, and used for sheet piling. Otherwise steel sheet piling is used. With plank sheet piling, a row of piling is necessary outside of or in front of the sheet piling to carry a waling piece for support in lining up the sheet piling. As all timber is inside of the lines of the foundation and excavation is carried to low water or below, untreated timber is used throughout.

The deterioration resulting from alternate freezing and thawing and from contact with drifting ice with which concrete seawalls on the North Atlantic Coast must contend is not encountered on the Pacific Coast.

For the type of seawall which must be constructed in deep water and absorb the pounding of heavy seas the breakwater at Port San Pedro or Los Angeles Harbor is one of the best illustrations.

The rock foundation for this breakwater was dumped from two parallel lines of railroad trestle. The trestles were spaced as far apart as a Bay City Crane on one trestle could conveniently reach to unload large rock from cars on the other. In this way a rock fill of large rock about 100 feet wide was built to a height near high tide. This rock fill was allowed to settle and solidify for a year. Then it was smoothed off

on top and a dry rock masonry wall about ten feet high and twenty feet wide was laid up along the center of the rock jetty by breaking courses with large rock weighing around ten tons. This center wall breaks the wave action during storms.

The various types of seawalls are designed for construction of stone or concrete with a carefully proportioned aggregate, which is not readily acted upon by sea water, and are therefore considered to be of permanent construction. While the probability of some maintenance has been stated any maintenance required would so greatly depend upon local foundation and current conditions, the character of the country, rock used, etc., that no maintenance costs applying to the different designs in a general way are available.

At one location a Type "C" concrete seawall had been worn away several inches over a period of years by the gravel which the waves threw against it. This wall was recently given a six inch facing of heavily reinforced concrete; holes two inches in diameter were drilled in the face of the old wall and rods with split ends and wedges were set in and driven tight. The hole around the rod was then filled with cement grout. The rods fastened in the old wall were spaced 24 inches each way. The reinforcing of the new six-inch face was fastened to these anchors and holds the layer of new concrete snugly to the old wall.

Where the concrete faces of the old seawalls are showing slight wear it is planned to cover them with a coating of asphaltum. This is based on the theory that the more resilient surface will lessen the impact and also that any sand or gravel which becomes imbedded in the asphaltum will offer additional wearing surface. No costs have been obtained in connection with the application of asphaltum but the cost of applying a new six-inch surface of 1:2:4 reinforced concrete to a 500-foot section of Type "C" sea wall amounted to approximately $22.00 per cubic yard.

It was formerly the practice to remove the form lumber on completion of the concrete face but this is now left in place and lasts from one to two years against the wave action before being worn out by the sand and gravel which strikes it during stormy weather. Advantage also accrues to the concrete in that it is protected over the period during which it is continuing to harden.

(5) DESCRIBE DIFFERENT TYPES OF FENDER SYSTEMS FOR PROTECTING WHARVES AND RECOMMEND SUITABLE USES FOR EACH, INCLUDING COMPARISONS OF FIRST COST, SERVICE LIFE AND MAINTENANCE COST OF THE VARIOUS TYPES

The main object in fender design is usually the protection of the structure, which tends to place the burden of protecting the boat upon the navigator.

On the Great Lakes where tides and currents do not enter into navigation problems to a great extent, the practice has been to use very simple fender systems, even going so far at times as to construct a concrete docking face with a steel rail imbedded in the face as a guard. Some docks have one or two courses of oak fenders set into the face of the concrete on the theory that the boat crews must so handle their vessel that it is protected in berthing.

The fender system of piling and timber grillage which protects the piers of the lift span of the new double track railroad bridge across Suisun Bay near Martinez is unusual in that it is carried out from the piers for about 76 feet on the end of the pier which is on the right or starboard side as a boat approaches the opening. On the opposite end of the pier the fender system only extends out about 45 feet. The fender

protection was carried out in this way at the request of the shipping interests. Boats pass through an opening 290 feet wide in the clear on the water line and while they should steer for the center of the opening, there may be occasion to pass other boats near the span. Captains also have a tendency to hold over toward the right-hand side. It was stated by navigators that they would feel safer if they had extra protection on the starboard side as they approached the opening. In addition to an extensive timber grillage and a large number of fender piles, the fender system is unusual in having a fender strip of timber 24 inches square which runs around the ends and along the channel side of the piers supported as a cap on the heads of the outside row of piling. Bolted to the face of the 24 $\times$ 24-inch timber are three parallel rows of 90-lb. steel railroad rails, set close together with their bases to the timber. The steel rails form a rubbing strip that cannot be easily bent and which should protect the fender system behind it from damage. The water is only 30 feet deep but bed rock is 155 feet below the water surface and the very fluid character of the upper portion of the mud necessitated the use of 110-foot piling in the fender system.

Plate III illustrates fender construction as placed at ordinary docks. It shows the framing, fender pile and belay pile as generally used for tying up boats in 30 to 40 feet of water where tides and currents are not unusually severe. It should be noted that untreated piles are used for fenders. This is for two reasons; first, the greater strength of untreated timber; and second, the abrasion of fender piles by boats would soon wear away the treated shell exposing the piles to marine borer attack.

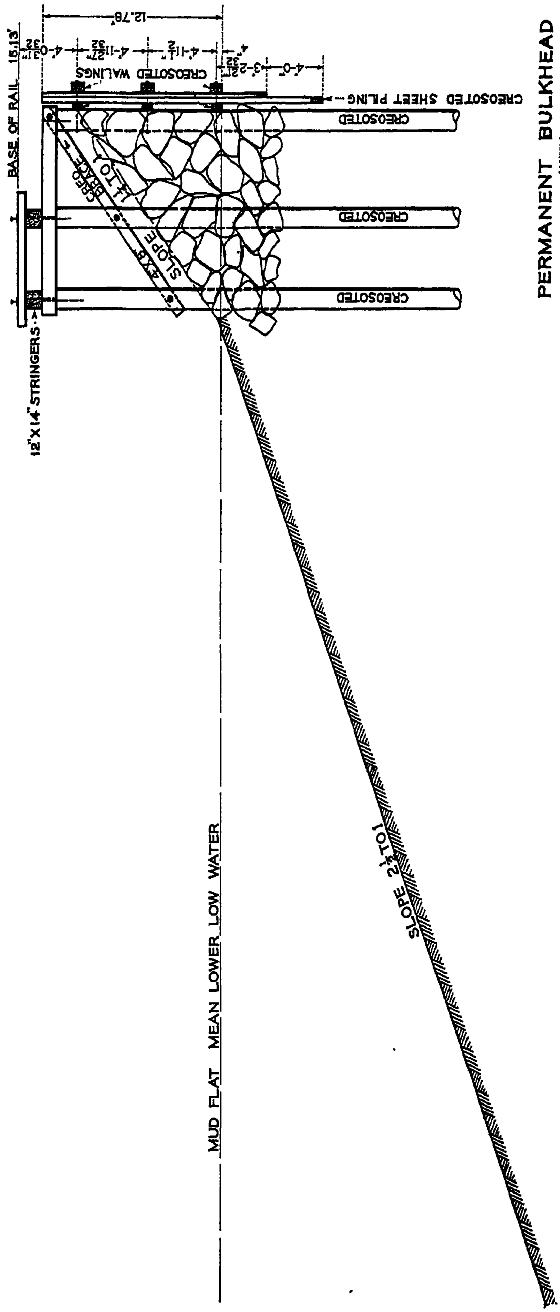
Plate IV illustrates the use of short or stub fenders by the Oakland Port Commission where the water is sufficiently deep to justify hanging the fenders from the wharf.

For ordinary passenger ferry slips two rows of spring fender piling are used with three tiers of ribbing; two rows of ribbing plank to each tier and each row made up of four 3 in. $\times$ 12 in. planks. For car ferry slips under the same conditions three rows of spring fender piling are used with four tiers of ribbing; three rows to each tier and each row made up of 3 — 4 in. $\times$ 14 in. planks thoroughly spiked together. In both systems of spring fender piling an untreated dummy pile is hung from the ribbing alternating with the treated piles for the full length of the slip on the inside. The dummy piles reach below low water and have the bottom end beveled to prevent possible uplift from floating timber or a boat guard rail. To take the wear from the rubbing of the guard rails of the boats, untreated sheathing 6 in. $\times$ 8 in. $\times$ 20 ft. is spiked at 45 degrees with the horizontal to the dummy piles which hang from the ribbing and alternate with the treated piles on the inside face of the slip.

The apron dolphin clusters are connected across the top with heavy rods. The ends of the rods project behind the pile clusters and on the rods behind the piles are placed heavy steel coil springs backed up with large washers and nuts. When the pile clusters bend apart as a boat noses in between them the springs are compassed and crowd the piles back to a snug fit holding the bow of the boat from any movement sideways.

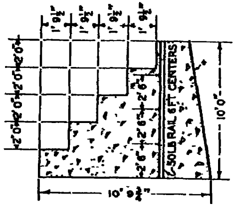
At docks, particularly reinforced concrete docks, heavy coil springs are often placed between the dock and the spring piling to prevent the spring piling from being driven against the dock with the impact of a blow.

The fender sheathing placed on the inside of slips on the Pacific Coast is usually fir or spruce except that on the apron dolphin clusters a hard wood, such as laurel or oak, is used. Slips must fit the bow of the boat snugly near the apron and the sheathing at this point is only three inches in thickness. The fir or spruce sheathing must have a thickness of six inches to wear well, the usual sheathing being of 6 in. $\times$ 8 in. pieces laid flat. Where three-inch sheathing is used the hard wood is the more economical. The average life of slip sheathing is from three to four years and the cost of renewal averages $25.00 per thousand f.b.m. for labor, to which must be added the lumber cost.

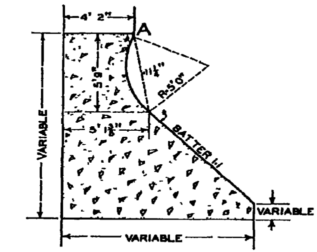


PERMANENT BULKHEAD WITH TRACK ON CREOSOTED PILING

PLATE I

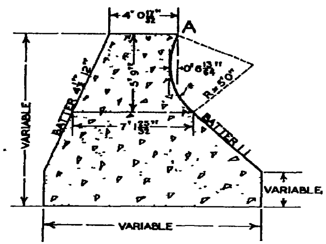


TYPE A SQUARE SECTION

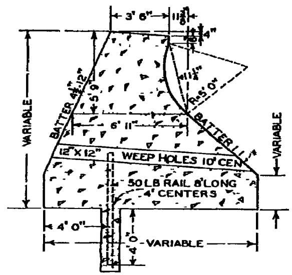


TYPE C CURVED SECTION

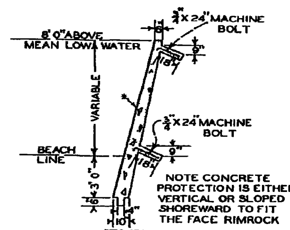
DETAIL A



TYPE B CURVED SECTION



TYPE D CURVED SECTION



TYPE E
TOE PROTECTION

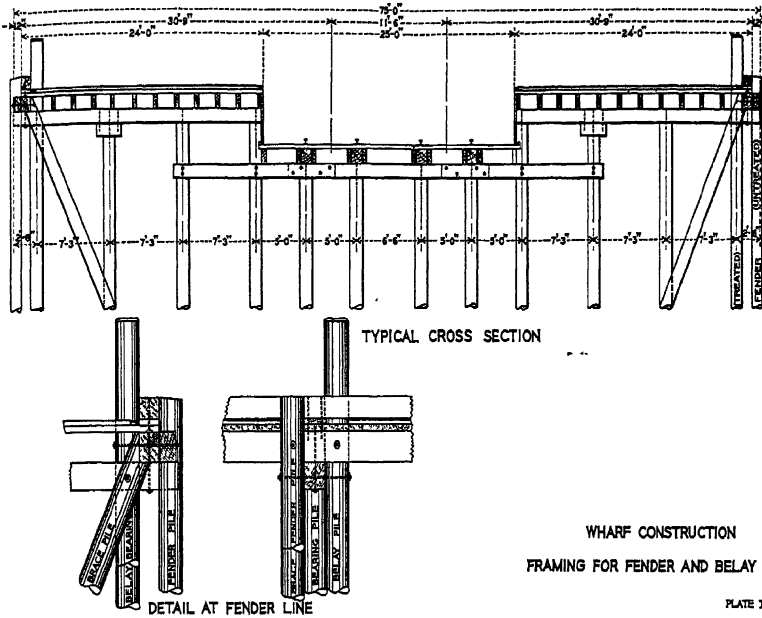
LOCATION	DATE BUILT	TYPE	LENGTH	AVERAGE HEIGHT	COST LIN FT	COST TOTAL
CONCEPCION	AUGUST 1909	A	150	12	30.82	4,623.45
TAJIGUAS	SEPT. 1909	A	432	10	21.00	9,074.48
TAJIGUAS	FEB. 1911	B	600	10	18.38	11,026.61
SACATE	JUNE 1911	A	520		39.94	20,768 15
SACATE	FEB. 1910	A	685	16	43.77	29,983.30
CONCEPCION	MARCH 1910	A	280	15	42.04	11,771.60
TAJIGUAS	APRIL 1911	A	800	10	23.33	18,665 50
CONCEPCION	AUGUST 1909	A	270	10	31.61	8,557.50
DRAKE	APRIL 1910	A	500	12	29.83	14,914.16
SACATE	APRIL 1911	B	350	12	34 06	11,927.24
CONCEPCION		B				
TAJIGUAS		B				
TAJIGUAS	AUGUST 1911	B	65	12		
CONCEPCION	MARCH 1914	B	200		77.75	15,550.00
CONCEPCION			1848	15	42 65	78,820.00
TAJIGUAS	APRIL 1914	B	350		31.43	11,000 00
SACATE	MARCH 1915	E	550		66.48	36,560 00
LENTO	DEC. 1915		300		33.73	10,120 00
CONCEPCION						
LENTO	1919	B	613	11	53 80	32,969 00
HONDA	JULY 1923	E	3390	23	9 87	33,471 20
SACATE	OCT 1921	E	696	9	5.74	3,997.13
SUDDEN	OCT. 1921	E	205	8	9 72	1,994.04
LENTO	OCT 1921	E	350		12 16	4,254 53
LENTO	APRIL 1929	C	1100	7	45 55	*55,452.81
GAVIOTA	JAN 1929	D	677	15	55.20	*47,679.73
SACATE	AUGUST 1929	D	170	11	207.68	35,302.12
SACATE	AUG' 1928	D	403	13		
DRAKE	FEB 1930	D	410	10	71 44	29,290.39
SACATE	JAN 1930	D	200	9	81 79	16,359 21

*COST INCLUDES $5,343 87 FOR GUTTERS ETC
*COST INCLUDES 10,308 20 FOR BACKFILL

* ASPHALTUM PROTECTION
FACE OF CONCRETE IS GIVEN AN ASPHALTUM COAT AS PROTECTION FROM WAVE ACTION AND IMPACT OF SAND AND GRAVEL

TYPES OF SEA WALLS

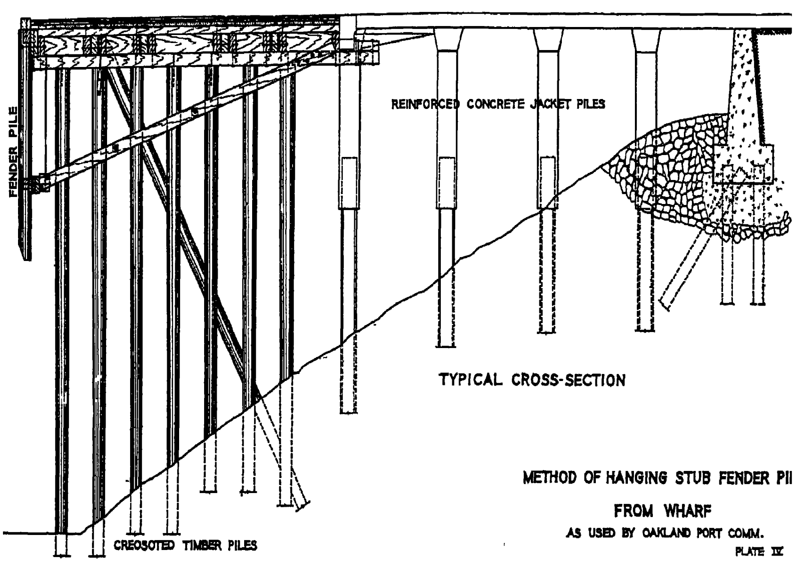
PLATE II



WHARF CONSTRUCTION

FRAMING FOR FENDER AND BELAY PIL

PLATE III

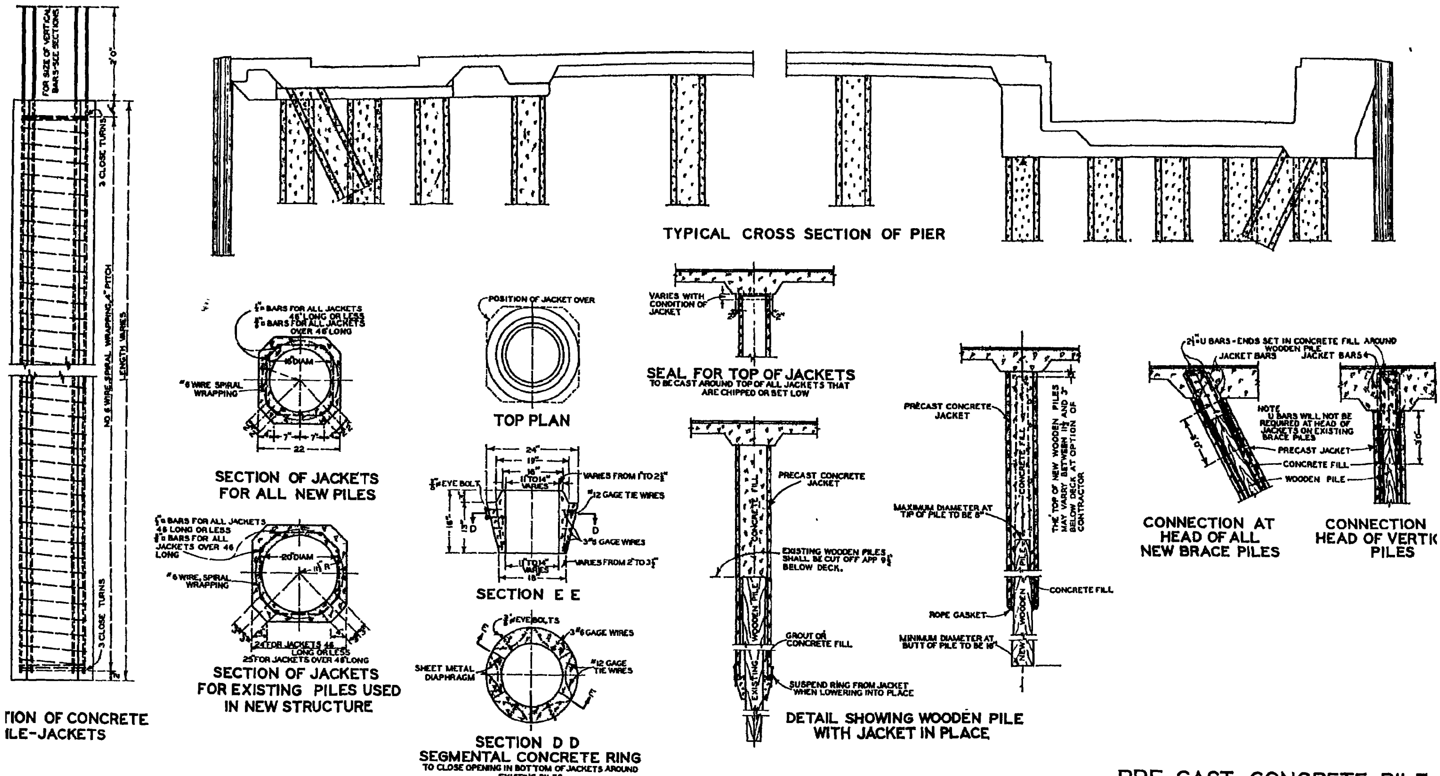


METHOD OF HANGING STUB FENDER PIl

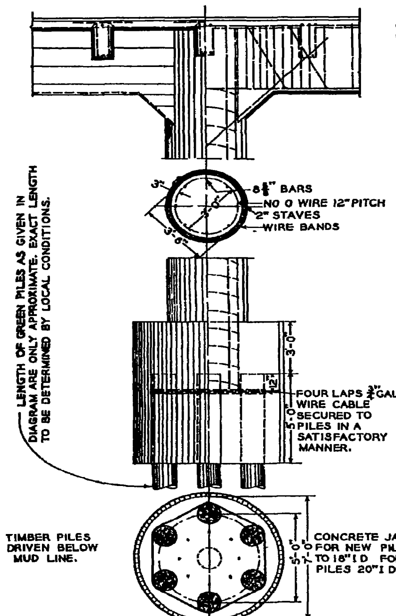
FROM WHARF

AS USED BY OAKLAND PORT COMM.

PLATE IV

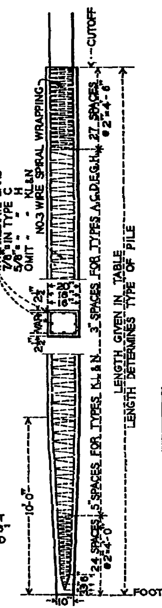


PRE-CAST CONCRETE PILE

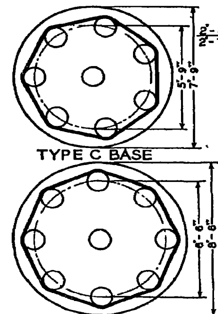


DETAIL FOR CONCRETE CYLINDER AND FOOTING

TYPE A BASE (NO CTR PILE)
TYPE B BASE (WITH CTR. PILE)



REINFORCED CONCRETE PILE

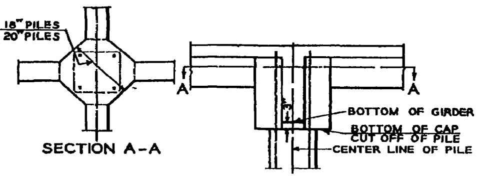


TYPE C BASE

TYPE D BASE

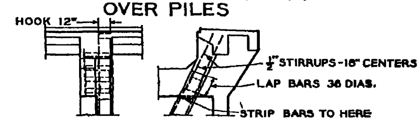
TYPE	LENGTH	SECTION	REINFORCEMENT
A	85'-92'	20"X20"	8-1" ϕ BARS
C	81'-84'	20"X20"	4-7/8" & 4-1" ϕ BARS
D	77'-80'	20"X20"	8-7/8" ϕ BARS
E	69'-76'	18"X18"	8-7/8" ϕ BARS
G	61'-68'	18"X18"	8-3/4" ϕ BARS
H	57'-60'	18"X18"	4-5/8" & 4-3/4" ϕ BARS
K	43'-56'	16"X16"	4-7/8" ϕ BARS
L	33'-42'	16"X16"	4-3/4" ϕ BARS
N	BELOW 33'	16"X16"	4-5/8" ϕ BARS

CAP TO BE USED FOR SUCH PILES AS ARE NOT SO DRIVEN AS TO PERMIT SATISFACTORY FRAMING OF BEAMS.



SECTION A-A

DETAIL OF CONCRETE CAP OVER PILES



DETAIL FOR BRACE PILES

PRE-CAST CONCRETE PILES AND CAST IN PLACE CYLINDERS

PLATE VI

Appendix D

(6) DESCRIBE TYPES OF WAREHOUSE PIERS, COAL AND ORE PIERS, CAR FLOAT PIERS AND OTHERS WITH RECOMMENDATION AS TO THE TYPE SUITABLE FOR USE UNDER VARIOUS CONDITIONS, INCLUDING COMPARISONS OF FIRST COST, SERVICE LIFE AND MAINTENANCE COST OF THE VARIOUS TYPES

W. H. Kirkbride, Chairman, Sub-Committee; W. D. Faucette, W. E. Hawley, C. R. Howard, J. A. Parant, C. U. Smith, R. C. Young, R. O. Rote, W. R. Swatosh.

Docks

The docks considered are of the types built to meet ordinary conditions, where the change in water surface due to the rise and fall of the tides is something less than fifteen feet, which do not require closed docks with gates. Local conditions such as channels, tidal currents and the arrangement of slips for ease of approach are not considered herein. Docks constructed of solid masonry, or mass concrete deep water retaining walls, are not used because of the great cost of such construction, particularly for the ordinary mud bottom.

Thirty-five years ago wharf and pier supports on the Pacific Coast were mainly untreated piles and were of very short life in waters infested with marine borers. More recent construction is of creosoted piles, piles sheathed in copper or encased in concrete or some form of patent built-up piles. All of the above improvements on the untreated pile have been developed as a protection against borer attack. The sheathed and built-up piles have not proved very satisfactory on account of their liability to injury in handling or from contact with boats or floating timber after driving.

Pile Repairs

During the period 1895 to 1915 much experimenting was done in the making of repairs on borer infested piles. Following a series of dry years and increased diversion of water from the rivers for irrigation purposes, harbor waters formerly so fresh that no trouble was experienced from borer attack, would become salty on account of insufficient fresh water coming in. Untreated piling would then show rapid attack from the salt water borers and many designs of forms were developed for encasing the piling in concrete.

Concrete Poured Around Piles

Where the water was sufficiently shallow or where the ground was exposed at low tide very material success was had in building forms around the piles, working the forms down into the mud below the line of future dredging or scour, cleaning out and sealing the bottom. After cleaning out the form to the bottom concrete was placed through a pipe to fill the form to a point 25 feet below the top. When this bottom concrete had set sufficiently the form was pumped out and filled with concrete to the top. Forms were made of both wood and steel and were often left in place after the concrete had hardened, but the successful work depended upon getting the form down so far that the bottom of the pile would not be uncovered at a later date, and on having the form sufficiently tight to prevent the dilution of the concrete mixture with salt water.

Light sheet steel forms which can be built up in the field by cold riveting with a gasket between the seams to make them water-tight were very successful. Underneath a wharf where the ground was not uncovered at low tide and it was necessary to work from a boat, the forms were hung from above and lowered down as they were built up. Spring straps were riveted to the inside of the forms to keep the sheet steel at a uniform distance from the pile.

From the records and reports of the Board of State Harbor Commissioners of California, several hundred piles on San Francisco Bay were jacketed with concrete as far back as 1896 and where steel forms were used and the work carefully done many of these piles are still in place. From 1903 to 1906 about 3000 pile jackets constructed with wooden forms were used on San Francisco wharves, but few are still in service at the present time.

In 1908 the Standard Oil Company wharves were in serious trouble from toredo and limnoria attack of untreated piling. Some 1100 of the copper sheathed piles which had been in the water three or four years, had been damaged by drift and were showing borer attack along with the unprotected piling. About 2000 of these piles were encased in concrete jackets using light steel forms twenty inches in diameter and with inside lugs to center them on the pile and but few have been replaced.

In 1910 a pier was constructed at San Francisco on which full length wood stave forms were used provided with a special shoe and rope gasket on the bottom of the form to exclude mud and water. Of 770 piles so protected in 1910 light repairs had been made to seventeen in 1925 but none had been replaced.

Some repairs have been made with Gunite Coating, and Gunite Coated piles have been used in construction the same as copper sheathed piles, but like the copper sheathed piles the Gunite Coated Piles are easily damaged from impact with boats or drift and in addition they must be worked down with a water jet to position as the blow of a pile driver hammer is very likely to crack or loosen the Gunite Coating.

Creosoted Piling

In the transition from untreated timber to treated timber and reinforced concrete, about every kind of painted and protected pile has been tried as a substitute for creosoted piles. Piles have been painted with marine paints, covered with protective fabrics and redwood battens which are held in place by nailing or wire wrapping and the pile again painted. Painted and built-up piles have been proved only a temporary expedient.

Creosoted piling and creosoted timber have proved the most dependable substitute for reinforced concrete. The Marine Piling Report to the American Railway Engineering Association for 1930 covering piles on the Pacific Coast, which have been driven for test purposes and observation, lists old creosoted fir piles driven in 1890 in San Francisco Bay and redriven in 1919 and 1920 at Seattle, Tiburon on San Francisco Bay, San Pedro and San Diego which show no attack from marine borers to date and are still in good condition after forty years in salt water. It is, of course, necessary in the handling of creosoted piling or timber that care be used to insure that the creosoted shell which varies from ¾ inch to one inch in thickness is not punctured. When this material is rafted pile poles and pile dogs must not be used where punctures of the creosoted shell would come above the mud line.

From 1909 to 1915 new piers were constructed at San Francisco in which approximately 23,000 creosoted piles were used. By 1922, 343 piles had been replaced and 4100 had been repaired between high and low tide. This was mostly due to careless handling on the part of the Contractor and puncture of the creosoted shell, although some piles are damaged through abrasion of the shell by small boats and by drifting timber. The

repairs are made by cleaning out the holes resulting from abrasion and limnoria attack and filling with cement mortar which is protected from the water during setting by a covering of plaster of paris. Such repairs can only be made above the low water line and similar defects below the line of low water ultimately necessitate the replacement of the piles which are attacked.

All creosoted piles, where the tops are cut off or where the creosoted shell is broken in framing or bolting, must be carefully painted with a preservative paint containing creosote oil. All creosoted timber must be similarly treated wherever the creosoted shell is broken and also all contact surfaces where the timber is likely to gather and hold moisture should be given a final cost of preservative creosote oil paint at the time of erection.

Creosoted piles that are carefully handled in the raft boom and properly protected where the surface is broken in framing can probably be safely estimated to have a 30-year life. Where docks are being extended in water that would require piles more than 80 feet in length the extension is usually made with creosoted piles.

Pre-Cast Concrete Cylinders

Untreated timber piles have been very successfully protected by setting a reinforced concrete cylinder over the pile with the pile driver on completion of the driving. The hazard in protecting untreated piling with concrete is that if the concrete shell is broken or the ground line is lowered below the concrete by dredging or currents, the pile becomes subject to borer attack. Between 1903 and 1910 several piers were built in which the untreated piles were protected in this way, but the concrete cylinders were not properly reinforced and most of the piles have been replaced with creosoted piles.

Between 1908 and 1911 a considerable number of carefully reinforced concrete cylinders were placed over untreated piles after driving and to date none of these piles has been removed. The State Harbor Commission's reports show that the last diver's examination found the piles to be in good condition. The California State Board of Harbor Commissioners adopted untreated piling, protected by reinforced concrete cylinders as the type of foundation to use in certain deep mud area in 1911. These concrete cylinders were 20 inches in inside diameter and three inches thick and were made in lengths to extend eight feet below the probable mud line when this was lowered by dredging to minus 46 at the side of the pier. The concrete cylinders were made horizontally in one length in the yard and carefully handled to the barge to avoid cracking. They have been successfully used in lengths as great as fifty feet. Some experimenting has been done in filling between the pile and the cylinder with sand instead of concrete but this is not satisfactory as a small break in the cylinder allows the sand to sift out and concrete with ¼ inch rock or coarse sand is generally used.

Pre-Cast Concrete Jackets

Plate V shows the reinforced concrete jacket now used and which is known as a modification of the Koetitz patent. The section of concrete jacket to be used for new piles has an internal diameter of sixteen inches while the section designed for placing over existing piles has an internal diameter of twenty inches. The improved pile jacket has been developed by Frank G. White, who has for many years been Chief Engineer of the Board of State Harbor Commissioners at San Francisco. The use of the 16-inch internal diameter jacket is made possible by driving the new untreated piles, butt down, and setting the jacket over the piles after driving.

Referring further to Plate V—sections are shown of the new wooden pile and the existing wooden pile with the concrete jackets in place. The concrete jacket must

come above the pile and be filled with concrete to permanently protect the pile head. Rope gasket has been used to center the concrete jacket over the new wooden pile but this is not very satisfactory as the rope has a disposition to roll up under the concrete jacket, as it is shoved down over the pile, often wedging the jacket tight or splitting it. For this reason a concrete ring has been designed which is cast in two sections and suspended from the jacket around the pile. As the jacket is lowered into place the ring plugs the bottom to keep out mud and water.

This segmental concrete ring or grommet is cast with four eye bolts and reinforced as shown in sections DD and EE—Plate V.

When the grommet is suspended from the jacket a rod can be passed around the grommet resting on the eye bolts, with the ends of the rod connected by a coil spring. The rod and spring hold the grommet snug against the pile as the jacket is shoved down over it, thus closing the opening at the bottom.

Sections are shown illustrating the connecting of the concrete jackets, which have been set on the piles, to the concrete caps. If the jacket is set low on the pile a seal is cast around the top of the jacket. The economic length of concrete jackets has been found to be about fifty feet. The piles which have been driven butt down and then jacketed have proven very satisfactory and this is one of the latest types of dock foundation.

Concrete Cylinders Protecting Pile Clusters

Plate VI shows the dimensions used for concrete cylinders for clusters of seven, eight and nine piles. Precast cylinders have been in use for many years but are large and hard to handle when used for multiple piles and the principal pile cluster protection has been with cast-in-place cylinders. Both steel and wooden forms have been used but the steel forms are generally favored. The forms are sunk below the line of estimated future scour and are filled solid with concrete to the high water line from which smaller concrete piers, as shown on Plate VI, are often used to support the deck.

In 1912, when the type of wharf construction that should be used was being studied for a portion of the San Francisco waterfront where the foundation was hard pan overlaid with a thin layer of mud, concrete cylinder piers of sufficient diameter to develop stability were given consideration as the most appropriate construction for this location. For the construction of piers or wharves where there was a very shallow layer of mud above a hard pan foundation, it was considered that if piles were driven this shallow layer of mud would give a very unstable support and a filling of small rock would be necessary around the piling to give the necessary lateral stiffness. As such filling would in a measure obstruct the tidal currents, it was not favored by the port authorities and the only remaining suitable type of wharf or pier construction was with the reinforced concrete cylinder supports filled with concrete.

From 1909 to 1918 new piers were built at San Francisco using some 4750 cast-in-place cylinders. Three hundred had been removed in 1913 and by 1922 repairs had been made on 514 cylinders. Most of the trouble developed in two piers built in 1913 where careless workmanship was clearly evident. Also most of the trouble was at construction joints, below high water, where the pouring was interrupted to permit of placing deck forms and was evidently caused by salt water getting into the cylinder forms. Since 1922 further repairs have not been necessary to the cylinders and when carefully placed this type of construction is considered satisfactory.

Reinforced Concrete Piles

Solid reinforced concrete piles were not used on the Pacific Coast until about 1911. Plate VI shows the detail and reinforcing for solid concrete piles up to 92 feet

in length. Since 1911 many thousand have been used and examinations by divers indicate practically no defects below the water line. Concrete piles have been successfully used on wharf work up to a length of 106 feet. They were twenty inches square and reinforced with eight one-inch bars. These very long and heavy piles weighing 23 tons each were used on the extension of San Francisco Piers Nos. 29 and 35 in 1915 and were successfully handled and driven. They are believed to be the longest piles of this type used. Care is, however, necessary not only in handling concrete piles but in driving same, that sufficient blow is not given to loosen the concrete from the reinforcing.

Inspections of the numerous concrete piles and concrete cylinders that have been used in pier and foundation work have shown many longitudinal cracks that have developed above the water line. While these are in no way serious they have been painted with an asphaltum paint or pitch to close the cracks and prevent moisture from reaching the reinforcing and corroding it.

Concrete Docks

The transition has been gradual from wooden decks and piling to concrete protected piling with structural steel beams replacing the timber caps. This construction was followed by reinforced concrete cylinder piers with structural beams encased in concrete and concrete slab decks. Since 1910 Pacific Coast docks and wharves on concrete supports have been mostly built of the concrete girder, beam and slab design. Some cracking has developed in the beams and girders of the deck system, but no cracking has shown in the deck slabs. To fill any cracks which had opened and prevent moisture from reaching the reinforcement and as a protection against moisture working into the concrete all exposed surfaces above the water are painted with a heavy coat of asphaltum water-proof paint.

Where timber decks are in service plank surfaces have been found objectionable, because of rapid wear, the rough planking making trucking more expensive and on account of the cracks in the planking and slivering from tractors and trucks which results in serious fire hazard. It has become general practice to cover planking, under heavy traffic, with asphaltum pavement. The surface of the trucking pavement is usually hardened by tempering with cement and marble dust.

Comparative Costs

Comparative costs of different types of dock construction were developed by Frank G. White, Chief Engineer of the Board of State Harbor Commissioners, at San Francisco, California, and were published in the World Ports Bulletin of February, 1925. A portion of this cost analysis is as follows:

"For the purpose of simplifying the comparison it is assumed that the structure to be analyzed is a simple pier approximately 100 feet in width, designed for a live loading of approximately 500 lb. per square foot. The costs include allowances for necessary brace piling but do not include fender lines, railroad track, or building supports, deck paving, mooring bitts, or other pier accessories. Costs are tabulated for three lengths of pile supports, fifty feet, seventy-five feet and one hundred feet. Stress assumptions for timber, steel and concrete are in acocrdance with the standards of the Board of Harbor Commissioners of San Francisco. The bearing capacity for timber piles is assumed at 27½ tons and for concrete piles at 40 tons. Creosote treatment is the standard 12 lb. and 6 lb. treatment for piles and timber respectively. Concrete in piles, jackets and deck is proportioned one part cement to five parts selected aggregate.

"Cost assumptions are as follows:

"Untreated timber $35 per M; creosoted timber $70 per M; untreated piles 22¢ per linear foot; creosoted piles 68¢ to 75¢ per linear foot; cement $2.75 per barrel; concrete aggregate $2.75 per cu. yd.; reinforcing steel in place $70 per ton; pile driver and car-

penter labor $8.00 per day; concrete labor $5.00 to $5.50 per day; pile coating 60¢ pei linear foot of coating; concrete jacketing of piles $2.75 per linear foot of jacket. The costs as tabulated include allowances for plant, overhead and Contractor's profit."

COST PER SQUARE FOOT OF FLOOR AREA

Type of Structure	*50′ Pile*	*75′ Pile*	*100′ Pile*
Untreated piling and untreated timber deck	$0.77	$0.87	$0.97
Coated pile with 25′ protection and untreated timber deck	1.03	1.13	1.22
Coated pile with 40 ft. protection and untreated timber deck	1.18	1.28	1.38
Creosoted pile and untreated timber deck	1.17	1.47	1.78
Creosoted pile and treated stringers and caps	1.54	1.84	2.15
Concrete jacketed pile with 25 ft. protection and untreated timber deck	1.73	1.82	1.91
Concrete jacketed pile with 25 ft. protection and reinforced concrete deck	1.95	2.05	2.14
Concrete packeted pile with 40 ft. protection and reinforced concrete deck	2.59	2.69	2.78
Reinforced concrete pile and reinforced concrete deck	1.97	2.65	3.70
Concrete cylinder and reinforced concrete deck	4.48	5.70	6.40

"In the case of the concrete cylinders the last item of cost is based on a 75 ft. cylinder resting on a cluster of piles driven below the mud line."

Advantages of the Different Types

With creosoted piling specimens unattacked after 40 years in salt water it appears safe to estimate the life of creosoted piling and creosoted timber structures at thirty years. The cost of treated pile and timber structures is considerably less than the cost of concrete jacketed pile structures or concrete pile structures.

The timber structures are more elastic and for foundations where settlement may take place or where the structure may be subject to more than usual shock, the timber structures may be more desirable.

Warehouse Piers

Warehouse piers vary in width from 100 feet to 200 feet or more as considered necessary to the service for which the pier is designed. The length of the pier is governed by the physical conditions of the harbor and the length of the boats to be accommodated.

The design of pier sheds varies with the demands of shippers. The shed should be of ample size to house at least a full cargo. If storage beyond the limits of loading and unloading time is desired then the pier shed becomes a storage warehouse and should be of fireproof construction and of multiple stories to supply the space needed.

Piers handling coastwise freight and passengers may have side aprons for handling freight and elevated landing bridges for the use of passengers.

Pier sheds are often of light wood construction regardless of being placed on concrete fireproof piers. There is small advantage in the construction of a fireproof shed if it is to be filled with highly inflammable freight. As a fire control, sheds are often equipped with steel rolling doors and with fire walls spaced 90 to 120 feet constructed on a timber frame covered with galvanized iron or cement plaster. The sheds are also equipped with automatic sprinklers, thus securing a low insurance rate.

The practice has been to place rail facilities down the center of warehouse piers, one or two tracks on the wharf surface or depressed, as deemed most advantagous to shippers. Recently many shippers have favored flush tracks on the outside edges of warehouse piers between the shed and the edge of the dock. It is found that the tracks

in the center of the shed are a hindrance to trucking and teaming and further with tracks outside of the shed freight may be handled directly from ship's sling to cars if so desired.

Coal and Ore Piers

The superstructure of coal and ore piers is not here discussed as the design is more or less individual as determined by the requirements of each location. The foundation must be planned for heavier loads than is the general practice in wharf design, and this added foundation strength is often secured by placing timber cribs filled with rock.

Another type of foundation used for ore docks is thickly driven piling. A concrete bulkhead may be constructed on the channel side and strengthened with tie rods carried across to piling on the opposite side of the pier. The pier may be built on piles driven so close together as to form suitable foundation for a reinforced concrete mat or blanket over the entire foundation area. If the piles are driven in water, sand may be filled in to low water or to the height at which the piling can be conveniently cut off for the placing of a reinforced concrete blanket.

(7) RECOMMEND SIZE AND DEPTH OF SLIPS REQUIRED FOR ECONOMICAL OPERATION OF THE VARIOUS TYPES OF WHARVES AND TRAFFIC CONDITIONS, INCLUDING COMPARISONS OF FIRST COST, SERVICE LIFE AND MAINTENANCE COST OF THE VARIOUS TYPES

Size and Depth of Slips

Slips must be built to accommodate the largest boats in the service for which the docks are constructed and therefore may be of any size and depth up to the maximum necessary. Slips having berthroom for more than one vessel on a side should have sufficient width for a boat to pass in and out safely between boats at berth on each side. The largest slips which have been planned for future construction at San Francisco are 1100 feet long, 400 feet in width and have 40 feet depth of water at low tide.

At Portland, Oregon, on the Willamette River, the Municipal Terminal No. 4 has an area of 165 acres with a harbor frontage of 3035 feet and three slips. Slips 1 and 2 are 1500 feet long and 280 feet wide and are designed to accommodate three boats on each side with clearance for a boat to pass down the center. Slip No. 3 is 1012 feet in length on the north side and 900 feet on the south with a width of 220 feet. The piers bordering the slips are equipped with sheds for general cargo and open space also is left on the inner one-half of pier No. 2 for the handling of bulk freight and lumber. The City of Portland has adopted a standard of 35 feet depth at lower low water for berths and slips on their Willamette River frontage.

It is recommended that in considering the construction of any slips a comprehensive plan be prepared which will be elastic as possible, and which will permit of modification to meet changes in the requirements of commerce and shipping from time to time as these develop.

To secure this elasticity the width and length of slips should have a generous minimum and with wide slips and piers the use of both sides for berthing is assured.

It is recommended that for slips which are designed to accommodate large Army transports and the larger deep water vessels construction plans should consider the feasibility of providing for a minimum quay length of 1000 feet to permit the berthing of two of the larger vessels on a side and should have a width of 400 feet to permit of

easy berthing or departure when a vessel is at berth on each side of the slip. A 40-foot depth of water is also recommended. If the maximum depth of water is provided at the time of construction later trouble with wharf foundations as a result of dredging is likely to be avoided.

In recommending that places for future slips provide for a minimum quay length of 1000 feet it is considered that the layout should provide for the berthing of two vessels end to end as this will make for economy in the layout of track facilities, warehouse and dock construction and in the general handling of water-going freight through concentration of dock facilities on a smaller waterfront area. While currents and channel conditions often make the securing of slips of two vessel lengths out of the question, it is recommended that in planning slips the advantages and cost of securing slips of this length be carefully considered.

(8) HARBOR STRUCTURES

Considerable information has been secured by the Committee but it is not yet in such form that it can be at this time submitted to the Association.

REPORT OF COMMITTEE VII—WOODEN BRIDGES AND TRESTLES

H. AUSTILL, *Chairman;*
J. B. MADDOCK, *Vice-Chairman;*
F. E. BATES,
C. H. CHAPIN,
C. R. CHEVALIER,
H. M. CHURCH,
F. H. CRAMER,
R. G. DEVELIN,
THEO. DOLL,
W. R. EDWARDS,
A. F. FRENDBERG,
S. F. GREAR,
R. P. HART,
W. E. HAWLEY,
REUBEN HAYES,
W. B. HODGE,
C. J. HOGUE,
F. C. JAMES,
E. A. JOHNSON,
C. S. JOSEPH,
R. W. KENNEDY,
H. C. KOELZ,
J. A. NEWLIN,
G. W. REAR,
ARTHUR RIDGWAY,
C. P. SCHANTZ,
D. W. SMITH,
M. A. STAINER,
G. C. TUTHILL,
J. L. VOGEL,
WM. WALKDEN,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) Simplification of grading rules and classification of timber for railway uses, collaborating with other organizations dealing with this subject (Appendix B).

(3) Standardization and simplification of store stock and disposition of material reaching obsolescence, collaborating with other committees and organizations concerned (Appendix C).

(4) Overhead wooden or combination wooden and steel highway bridges, collaborating with Committees VIII—Masonry and XV—Iron and Steel Structures (Appendix D).

(5) Design of standard wooden trestles for heavy loadings.

(6) Relative merits of concrete and treated wooden trestles, collaborating with Committees VIII—Masonry and XVII—Wood Preservation (Appendix E).

(8) Bearing power of wooden piles, with recommendation as to best methods of determination (Appendix F).

(9) Best relationships between the energy of hammer and the weight or mass of pile for proper pile driving, to include concrete piles, collaborating with Committee VIII—Masonry (Appendix G).

Action Recommended

1. That no changes be made in the Manual at this time.
2. That Appendix B be received as information and the subject continued.
3. That the conclusions (1) to (13) inclusive in Appendix C be adopted for printing in the Manual and the subject discontinued.
4. That Appendix D be received as information and the subject continued.
5. The Committee reports progress and recommends the subject be continued.

Bulletin 341, November, 1931.

6. That Appendix E be received as information and the subject continued.
8. That Appendix F be received as information and the subject continued.
9. That Appendix G be received as information and the subject continued.

Respectfully submitted,

THE COMMITTEE ON WOODEN BRIDGES AND TRESTLES,
H. AUSTILL, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

G. C. Tuthill, Chairman, Sub-Committee; F. H. Cramer, W. E. Hawley, C. J. Hogue, Arthur Ridgway.

The Committee has no changes in the Manual to recommend.

Appendix B

(2) SIMPLIFICATION OF GRADING RULES AND CLASSIFICATION OF TIMBER FOR RAILWAY USES, COLLABORATING WITH OTHER ORGANIZATIONS DEALING WITH THIS SUBJECT

Wm. E. Hawley, Chairman, Sub-Committee; C. R. Chevalier, H. M. Church, A. F. Frendberg, Reuben Hayes, C. J. Hogue, R. W. Kennedy, J. A. Newlin, C. P. Schantz.

Due to conditions in the business and lumber industry no important work in grading rules has been done by the associations of manufacturers of lumber. Activities of these associations have been along promotional and trade extension in a time when the problem of sales and control of output was most pressing for attention. Activity in further development of grading rules has been suspended for the future. We have no revisions to report. The subject should, however, be continued on the Committee program.

A special assignment of collaboration on grading rules for car lumber and timber with the Mechanical Division, A.R.A. is before a Sub-Committee but conclusions have not been reached by the Committee and therefore only progress on the assignment may be reported.

Appendix C

(3) STANDARDIZATION AND SIMPLIFICATION OF STORE STOCK AND THE DISPOSITION OF MATERIAL REACHING OBSOLESCENCE, COLLABORATING WITH OTHER COMMITTEES AND ORGANIZATIONS CONCERNED

S. F. Grear, Chairman, Sub-Committee; A. F. Frendberg, R. P. Hart, Reuben Hayes, W. B. Hodge, C. J. Hogue, R. W. Kennedy, D. W. Smith, M. A. Stainer, J. L. Vogel, William Walkden.

The Sub-Committee has made use of data previously collected by the Committee on Wooden Bridges and Trestles, and finds a very great variety of sizes and lengths of

bridge materials. The Association has adopted several standards for timber trestles, but very little progress has been made in getting the various railroads to adopt these standards. The Committee feels that a more general use of the sizes and lengths shown on the plans for these Association standards would result in the simplification of manufacture of bridge timbers, and this, in turn would affect the simplification of storehouse stocks and permit the reduction of such stocks.

Some suggestions are proposed herewith, to bring about the simplification of stocks.

One railroad reports that all timber is shipped from one point and the hardware is also shipped to this storehouse and distributed with the timbers.

On one railroad all timber bridge material is shipped from one point direct to the job. Each bridge gang carries sufficient material on cars for about four panels of trestle for use in emergencies. No material is unloaded except where the work is to be done.

There seems to be little reason for bridge timbers reaching obsolescence, if store stocks are properly watched. Such material could ordinarily be used for repairing existing structures.

The Committee also desires to call attention to committee reports of Purchases and Stores Division, A.R.A., as follows:

"Report of Committee, Subject V—Forest Products, page 171 of May, 1925 Proceedings."

"Report of Committee, Subject XVI (A) Standardization and Simplification of Stores Stocks. (B) Disposition of Surplus or Inactive Materials, page 217 of June, 1928 Proceedings."

Conclusions

1. Materials of the same size for ties and for guard timbers should be used on steel bridges and timber trestles, where the design will permit. This would also be applicable to the hardware.

2. Timbers of the same cross-section should be used in open deck and ballast deck trestles, where both types are in use on one railroad; also the use of timber of standard cross-section for sills, caps or posts of frame trestles and other structures where the lengths cannot be standardized.

3. Sizes of material for timber trestles should conform as nearly as possible to the standard commercial size adopted as the American Lumber Standards.

4. Treated pile stubs should be used for foundations of buildings, eliminating the necessity of carrying stocks of timber for this purpose.

5. Suitable obsolete timber or timber of odd sizes should be used for mud blocks for frame trestles, platforms, buildings, crib walls, platform curbs and concrete forms. In some cases, it may be advisable to re-work such timber into smaller sizes.

6. Lumber rejected for other purposes may be used in temporary construction.

7. When a certain size or class of untreated timber or piling is overstocked, it may be found to be more economical to give it a light treatment for preservation of the sapwood than to attempt to dispose of it or re-work it.

8. Emergency stocks of timber carried at points other than general supply yards should be treated.

9. Plans should be prepared with a view of eliminating material which is not standard stock. This is especially important for treated material which must be seasoned before treatment.

10. The Engineering and Maintenance Departments should examine stock lists periodically and, when special material is to be ordered, determine if substitutions can be made from stock.

11. The Engineering and Maintenance Departments should keep the Store Departments informed as closely as possible on future requirements.

12. Store Departments should advise all departments concerned of special stocks or overstocks of materials.

13. Co-operation of all departments, such as Bridge, Building and Mechanical, with a view of reducing the number of standard sizes and grades of timber.

The Committee recommends that Conclusions 1 to 13 be adopted for the Manual; that the remainder of this report be received as information, and that the subject be discontinued.

Appendix D

(4) OVERHEAD WOODEN OR COMBINATION WOODEN AND STEEL HIGHWAY BRIDGES

R. P. Hart, Chairman, Sub-Committee; C. H. Chapin, F. H. Cramer, R. G. Develin, C. S. Joseph, J. B. Maddock, G. W. Rear, G. C. Tuthill, J. L. Vogel, Wm. Walkden.

Work of this Sub-Committee for the past year has been confined to study of the practical application for plans presented in its report for 1931. Plans were presented to and favorably commented upon by several state highway bridge engineers. Suggestions offered by the highway engineers are being considered in connection with proposed revision of typical plans.

In order that the members of the Association may fully appreciate the type of construction under consideration, the Committee offers the following pictures of bridges constructed in central Kansas during 1931 substantially in accordance with the typical plans presented by your Committee last year:

Fig. 1—Bridge for county road over Missouri Pacific new line, 1.62 miles east of Herington, Kansas. Roadway width 24 ft. between curbs. Panel lengths 21 and 23 ft. Concrete floor slab 6½" thick. Timber stringers 8 × 16 spaced 1'-11" centers. Round posts in bents used account skew, permitting elimination of filler blocks for bracing.

Fig. 2—Part of bridge illustrated in Fig. 1 showing framing of bents.

Fig. 3—Deck of bridge for county road over Missouri Pacific new line, 2.04 miles east of Hope, Kansas. Roadway width 20 ft. between curbs. 6½" concrete deck slab supported on 8 × 16 creosoted timber stringers and bents as illustrated in Fig. 2.

Fig. 4—Details of bridge illustrated in Fig. 3 showing creosoted timber construction below concrete floor slab.

Fig. 5—Details of endwall construction for bridge illustrated in Fig. 3 and 4.

The actual cost of constructing bridges shown in Fig. 4 to 5 approximated the estimated cost given in last year's report; i.e., approximately $3.00 per square foot of roadway surface. Bids of contractors also reflected the 10 per cent saving set up in last year's report for use of concrete floor slab in preference to laminated timber floor with asphalt plank wearing surface. Highway departments using this type of construction report excellent service and low maintenance costs for bridges in service 4 or 5 years.

FIG. 1.

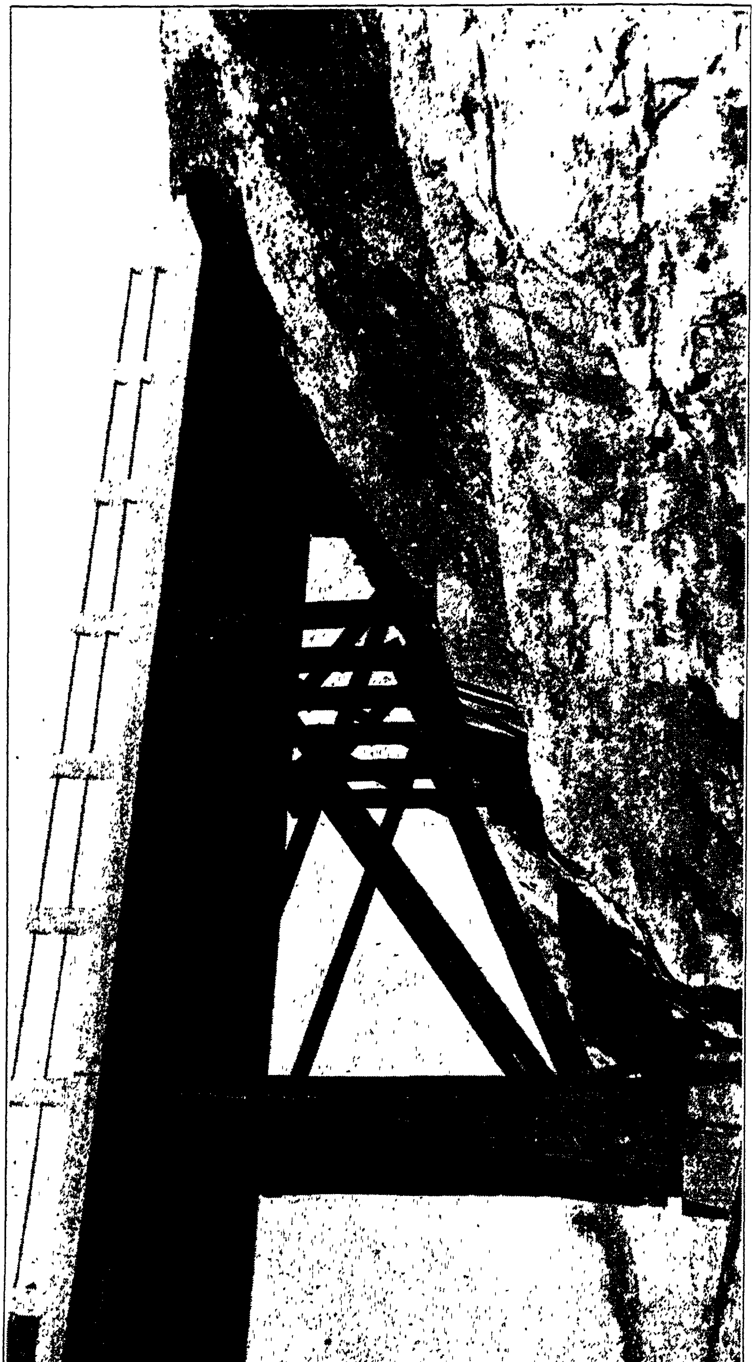


Fig. 2.

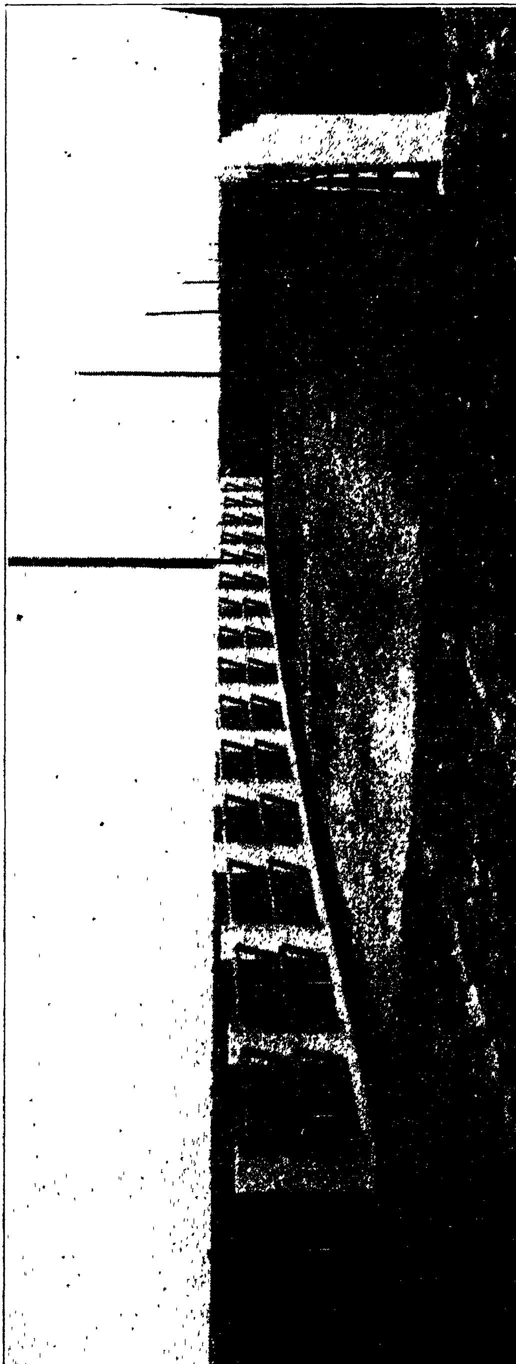


Fig. 3.

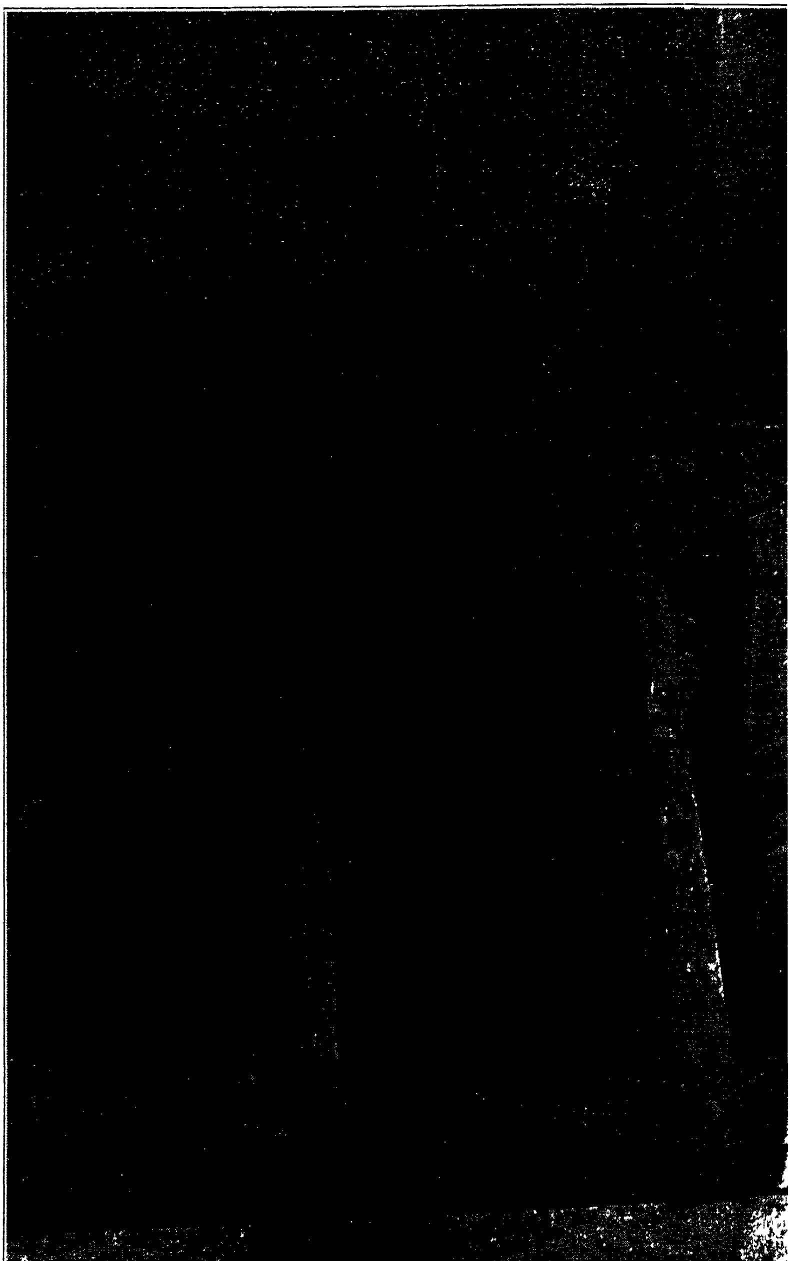


FIG. 4.

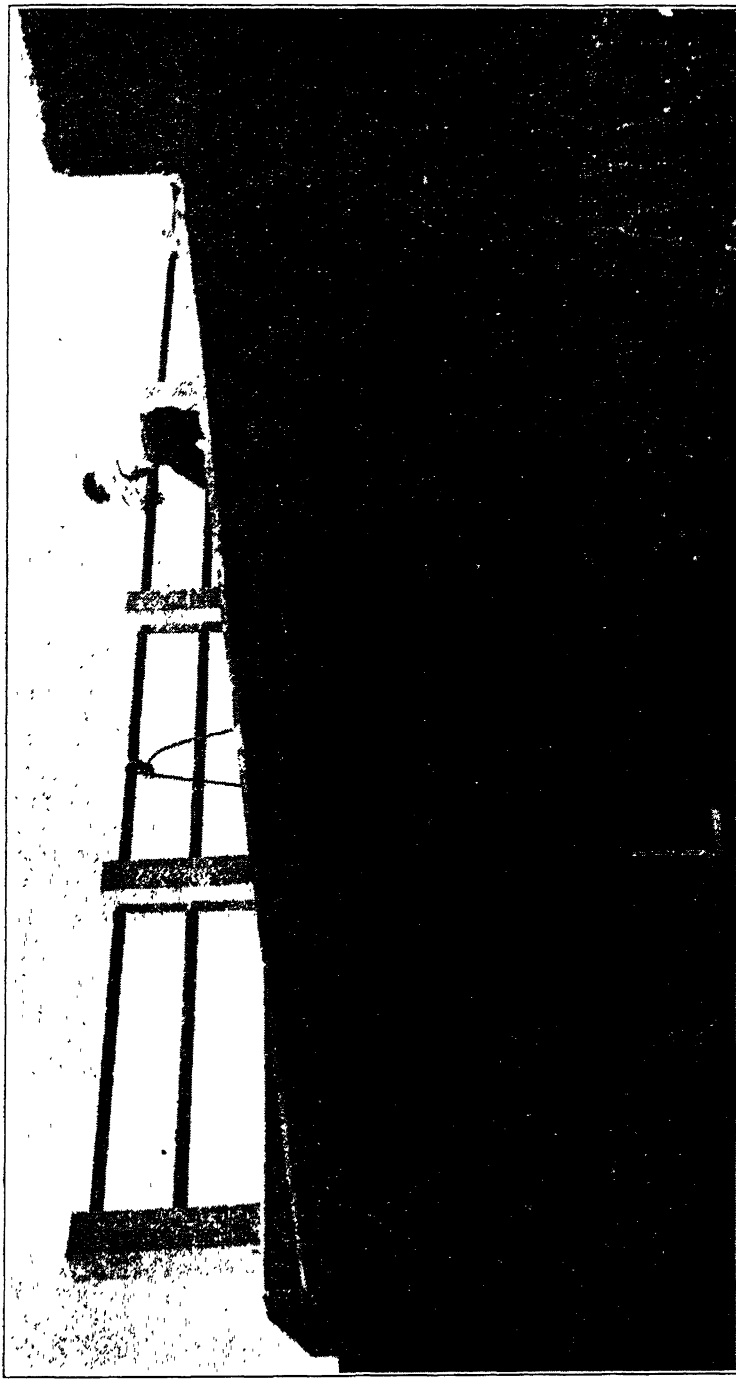


Fig. 5.

Attention is directed to Fig. 4 showing concrete fillers on caps between stringers to serve as a fire break and prevent the accumulation of dirt and trash. Your Committee proposes to incorporate this feature in revised plans. It also proposes to substitute 4 inch or 6 inch concrete curtains between stringers for timber bridging, thereby further reducing fire hazard.

Your Committee recommends that this report be received as information and that the work of the Committee be continued another year to study combination timber and steel highway bridges and give further study to the revision of details in plans previously submitted.

Appendix E

(6) RELATIVE MERITS OF CONCRETE AND TREATED WOODEN TRESTLES

Arthur Ridgway, Chairman, Sub-Committee; F. E. Bates, F. H. Cramer, S. F. Grear, C. J. Hogue, C. S. Joseph, R. W. Kennedy, H. C. Koelz, J. B. Maddock, J. A. Newlin, G. W. Rear.

The conclusions reached and adopted by the Association as a result of the Committee's previous report on this subject were necessarily of a general character because of the utter lack of essential data. To now return conclusions of a more specific nature requires reliable cost data which the Committee had previously been unable to obtain for the very good reason that it was not then extant.

There are available to the Committee only two lines of activity, both of which are necessary to final disposal of the subject: (1) the evaluation in monetary terms of certain advantages inherent in each of the two types of structures, and (2) the annual cost of maintenance including interest on investment during the entire serviceable life of each. Both these phases of the matter are receiving the attention of the Committee but, because of the absence of pertinent detailed and specific data in records as kept by carriers generally, progress in its assembly must necessarily be slow. To this difficulty is added the apparently unsurmountable task of predicting the average length of useful life of long-lived structures, the oldest of which have been in use for perhaps less than half their probable serviceable age.

It may be that the Committee will eventually have to acknowledge as before the impossibility of obtaining reliable cost data and of developing a satisfactory method of monetary comparison of elements heretofore considered intangible, but notwithstanding the meager results of the past year's efforts, no doubt partially due to prevalent adverse conditions, it is still hopeful of some measure of success in the undertaking and accordingly requests a continuation of the subject.

Appendix F

(8) BEARING POWER OF WOODEN PILES, WITH RECOMMENDATIONS AS TO BEST METHODS OF DETERMINATION

W. R. Edwards, Chairman, Sub-Committee; F. C. James, H. C. Koelz, G. W. Rear, C. P. Schantz, M. A. Stainer, G. C. Tuthill, J. L. Vogel.

This Committee makes the following report and recommends that it be received as information:

In setting up a method for determining the bearing value of piles, two general cases are to be considered:

(1) Piles in pile trestles, or in the foundation for frame bents in frame trestles;
(2) Piles in foundations of concrete or masonry structures.

In the first case the requirements are less exacting, as the load on a single pile under E–50 loading up to spans of 16 ft. will not exceed 20 tons. Even where trestle piles are found to be overloaded, and gradual settlement results, this can be taken care of by shimming, or additional piles can be driven, if necessary, at relatively small expense. In the case of foundation piling, it is important to keep the loads well within the safe bearing value, as any settlement may result in serious injury to the superimposed structure, and involve a heavy expense to secure the proper support.

Two methods of determining the safe bearing value are available, the use of a formula based on the behavior of the pile in driving, and the use of test loadings.

An exhaustive mathematical discussion of this subject was offered in 1902 by Ernest P. Goodrich, Mem. Am. Soc. C.E., and published in Vol. XLVIII of the Transactions of that Society. The general formula deduced, containing a large number of variables, is not adaptable to practical use, as numerous assumptions are necessary to simplify it to workable form. In this paper and the discussions, there are listed 18 other formulae which have been proposed, the results of which differ widely, indicating the impossibility of arriving at exact results by this method.

In the August 1931 Proceedings of the Am. Soc. C.E. (Vol. 57, No. 6), there is published a Bibliography of Physical Properties and Bearing Value of Soils. This list contains approximately 800 references of which 151 relate to piles, about one-half of these references having to do with formulae and tests for determining bearing values.

This Bibliography has brought to the Committee's attention material which it has not yet had time to consider and it is recommended that the subject be carried over until next year to permit further study.

The formula most generally employed is the one known as the Wellington, or Engineering News formula. This is:

For drop hammer,

$$P=\frac{2\,Wh}{S \text{ plus } 1}$$

For steam hammer,

$$P=\frac{2Wh}{S \text{ plus } 0.1}.$$

in which

P = safe load in pounds.
W = weight of hammer in pounds.
h = fall of hammer in feet.
S = penetration, or set, under last blow, in inches.

For a 2,000 lb. hammer falling 20 ft. and giving a 1 inch penetration on the last blow, this represents a bearing value of 20 tons. There are certain conditions to be met in making this determination. The most essential are that the fall be so regulated that there will be practically no bouncing of the hammer, and the sinking of the pile must be sufficiently uniform to indicate clearly that the point is moving freely and is not being mashed or broomed by overdriving against a hard surface.

This method of determination is supposed to give a factor of safety of 6, and, where the results of the formula have been checked by test loadings, the latter have almost invariably been found to be in excess of the computed safe load. Where uncertainty exists, as it does in a large proportion of cases, as to the material through which the pile is passing, this margin of safety is probably not too great; but where it is positively known that the material is of a uniform character, with no possibility of encountering local obstructions, an increase of the coefficient from 2 to 2.5, or even more, might safely be made.

For ordinary pile trestles, with spans from 12 ft. to 16 ft. and four piles to the bent, this formula will furnish a sufficiently close approximation to insure against settlement.

Where the pile rests on a solid stratum, with very little penetration, or where a considerable length of pile is above a firm ground line, the strength of the pile acting as a column becomes the determining factor, rather than the safe bearing value. In this case, the safe load for piles driven straight and in their proper position, without initial fibre stress induced by bending to bring them to place, may be determined by the formula,

$$S = Su\ (1—1/60d)$$

where S = safe load per square inch at middle of unsupported length;
Su = 600 for white oak and long leaf yellow pine, and 500 for Douglas fir and Northern pine;
1 = unsupported length in inches;
d = diameter at middle of unsupported length in inches.

In the case of foundation piles, where possibility of settlement must be avoided, and where knowledge of soil conditions or other elements of the problem render the application of a formula an insufficient safeguard, resort may be had to loading tests. These are generally made on a single pile in a group, or on a quadrilateral of four piles. It is open to question whether the results so obtained are more to be relied on than those determined by the use of the formula. The single pile may conceivably fail to represent an average of all of the piles taken singly, and its reaction to the test load may be influenced by the adjacent piles to an extent which would not obtain when these adjacent piles are also loaded. The same is true, sometimes to a greater and sometimes to a less extent, with all the piles in a group of four. The further complication arises with the group of four, that, unless the settlement of all of the four piles is equal, which it seldom would be, the loading platform is unevenly supported and the true average bearing value is a loose approximation at best. This difficulty is sometimes met by constructing a small foundation with dimensions proportional to the actual structure to be built, and testing this as a unit. The cost involved in this method

renders it impracticable except in the case of very important structures, which require special study and investigation and therefore fall outside the range of ordinary practice.

In view of the large amount of work which has been done on this subject by previous investigators, it is felt that any attempt to develop a new formula by original methods is uncalled for and that such an attempt would accomplish no results of practical value. It is hoped that this report will call forth constructive discussion which will aid the Committee in reaching final conclusions for recommendation to the Association next year.

Appendix G

(9) BEST RELATIONSHIPS BETWEEN THE ENERGY OF HAMMER AND THE WEIGHT OR MASS OF PILE FOR PROPER PILE DRIVING, INCLUDING CONCRETE PILES

C. R. Chevalier, Chairman, Sub-Committee; C. H. Chapin, Theo. Doll, A. F. Frendberg, W. B. Hodge, F. C. James, E. A. Johnson, M. A. Stainer.

It is common knowledge that there are three types of hammer in use: the drop hammer, now very little used; the single-acting steam hammer, which is a modification of the drop hammer; and the double-acting steam hammer, in which steam pressure accelerates the drop of the ram, and its energy at the pile head is considerably dependent upon the steam pressure, which also governs the number of blows per minute.

In general the heavier the weight, with respect to the weight of the pile being driven, the greater is the efficiency of the blow, and a rapid succession of blows with a heavy weight falling a short distance is more efficient than a lighter weight falling the necessary greater distance to obtain the same striking energy.

There is a considerable difference between the initial striking energy and the effective net energy in forcing the pile down, due to overcoming the inertia of the pile, the elastic compression of the pile and soil, and particularly in case of concrete piles, by the cushion used on top of the pile to prevent damage. This cushion varies so much on different railroads that it is difficult to determine the actual loss of energy from its use. Some use several coils of old rope, some several coils of old hose, and others use several layers of wood plank cut to fit inside the pile cap.

Another factor to consider is a ram heavy enough to prevent rebound. All of us have observed this action in the old style drop hammer when the pile had reached a certain "set". With the use of the heavy steam hammer having a short stroke, rebound seldom occurs.

Also the kind of pile, its use, as well as the desired result have considerable bearing upon the weight of the hammer to be used; for a heavier hammer, in relation to the weight of the pile, can be used in driving untreated wood foundation piles, than should be used in driving treated trestle piles, which must not be splintered or split, if the proper life is to be obtained.

Economical driving is also governed by the requirements and the soil into which the piles are driven, such as:

(1) A certain required penetration, even in hard driving the entire distance;
(2) Soft material overlying rock or hardpan, where the load will be carried at the pile tip; and
(3) Soft material, or soft material gradually changing to stiff, where the load is carried by skin friction.

In order to obtain information from actual pile driving operations, questionnaires were sent to Committee members and data received is presented in Exhibit A.

From this information it appears that the railroads make general use of two sizes of hammer; light types for wood and short concrete piles with rated gross energy varying from 7260 to 9650 foot-pounds, and heavier types with rated gross energy of 15,000 foot-pounds for concrete piles 30 feet to 40 feet long.

In two instances still heavier types were reported, one for 60 ft. concrete piles and the other 67 ft., where hammers were used having rated gross energy of 22,080 and 24,375 foot-pounds respectively. In some cases water jets were used, and in all cases a cushion was provided on top of concrete piles.

The Raymond Concrete Pile Company and the Foundation Company were asked for suggestions but nothing of a definite nature was obtained. Ralph H. Chambers, Vice-President of the Foundation Company, advised that he is the chairman of a committee working up a report for the proposed new Building Code for the City of New York, in which they are to recommend that for concrete piles up to 18 inches in diameter a hammer with an energy of 15,000 foot-pounds be used, and over 18 inches in diameter one of 22,500 foot-pounds energy. Weights of piles varied so much that none were given except that they run from 150 pounds per foot minimum to 320 pounds per foot for an 18-inch pile with the corners chambered.

The Missouri Pacific specifications in general, are that for wood piles a hammer with an energy of 7,260 foot-pounds be used, and for concrete piles one with an energy of 15,000 foot-pounds.

The following conclusions are presented as information:

(1) The hammer should be as heavy as possible without undue damage to a properly cushioned pile.
(2) For average driving conditions, all kinds of piles, the rated gross energy of the hammer in foot-pounds should be twice the weight of the pile.
(3) For soft driving, to rock, from one to two times the weight of the pile.
(4) For hard driving, from two to three times the weight of the pile.

EXHIBIT "A" of Appendix G

Road	Location	Structure	Pile: Kind	Pile: Length	Pile: Weight	Hammer: Type	Hammer: Weight Hammer	Hammer: Weight Ram	Hammer: Length Stroke	Hammer: Strokes per min.	Hammer: Energy Foot Pounds	Ft. Lbs. Energy Divided by Wt. of Pile	
O.	Newport News	Coal pier	Concrete	67'	-	Dbl. Acting	8600	1540	21"	-	7200	-	Tried first and found ineffectiv
	" "	" "	"	67'	-	Single "	16250	7500	39"	50	24375	-	Used throughout the work.
	Cincinnati	Viaduct Ohio River Br.	"	35'	7700+	Dbl. "	10000	2500	20"	115	15000	1.95	Satisfactory.
	"	ditto	"	30'	6600±	" "	10000	2500	20"	115	15000	2.27	"
ent.	Ill. & Tenn.	Bridges	"	25'	5525	Single "	9600	5000	36"	60	15000	2.72	Too heavy with hood & 3 coils ro shattered piles.
	" "	"	"	27'	5967	" "	6700	3000	29"	70	7260	1.22	Satisfactory.
	" "	"	"	25'	5525	" "	6700	3000	29"	70	7260	1.31	"
	" "	"	"	20'	4420	" "	6700	3000	29"	70	7260	1.64	"
kD.C.	Texas	"	Pine-Tr.	65'	3250	Dbl. "	8600	1900	24"	110	9650	2.97	Satisfactory-Hammer broke so work completed with single acting hamm
"	"	"	"	65'	3250	Single "	6700	3000	29"	70	7260	2.23	Satisfactory.
"	"	"	Concrete	28'	5670	" "	6700	3000	29"	70	7260	1.28	"
"	"	Underpass	"	18'	3650	Dbl. "	6600	1900	24"	110	9650	2.65	"
ao.	Missouri	Br.Found.	Pine-Untr.	40'	2000	" "	6750	1500	16"	140	8200	4.10	"
	"	"	" "	35'	1750	" "	6750	1500	16"	140	8200	4.68	"
	"	"	Concrete	30'	6600	" "	6750	1500	16"	140	8200	1.24	Unable to get required penetratio heavier hammer used satisfactoril
	"	"	"	30'	6600	" "	13185	3625	20"	120	22080	3.35	Satisfactory.
	"	"	"	25'	5500	" "	6750	1500	16"	140	8200	1.49	"
	"	Ball.Dk.Tr.	Pine.Tr.	70'	4620	" "	6750	1500	16"	140	8200	1.77	"
	"	"	"	65'	4290	" "	6750	1500	16"	140	8200	1.91	"
	"	"	"	60'	3960	" "	6750	1500	16"	140	8200	2.07	"
	"	"	"	55'	3630	" "	6750	1500	16"	140	8200	2.26	"
	Kansas	Trestle	Pine-Untr.	50'	2500	" "	6750	1500	16"	140	8200	3.28	"
	"	"	Concrete	45'	9900	Single "	9600	5000	36"	60	15000	1.52	"
	"	"	"	40'	8800	" "	9600	5000	36"	60	15000	1.70	"
	"	"	"	35'	7700	" "	9600	5000	36"	60	15000	1.95	"
												60.47	
												2.08 Average	

REPORT OF COMMITTEE XIII—WATER SERVICE AND SANITATION

R. C. BARDWELL, *Chairman;*
W. R. ANTHONY,
W. M. BARR,
R. W. CHORLEY,
R. E. COUGHLAN,
W. L. CURTISS,
J. H. DAVIDSON,
B. W. DEGEER,
L. E. ELLIOTT,
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J. H. GIBBONEY,
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P. M. LABACH,
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E. M. GRIME, *Vice-Chairman;*
W. B. MCCALEB,
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S. B. MITCHELL,
W. B. NISSLY,
A. B. PIERCE,
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H. E. SILCOX,
D. A. STEEL,
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R. A. TANNER,
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C. P. VANGUNDY,
H. W. VANHOVENBERG,
J. C. WALLACE,
J. B. WESLEY,
A. E. WILLAHAN,
R. S. WILSON,
F. D. YEATON,

Committee.

* Died December 18, 1931.

To the American Railway Engineering Association:

Your Committee on Water Service and Sanitation reports on the following subjects:

(1) Revision of Manual (Appendix A). Standard methods of water analysis and interpretation of results; specifications for salt to be used in regeneration of zeolite water softening plants. It is recommended that the standard methods of water analysis and interpretation of results, shown in the 1929 Manual, pages 921 to 925 inclusive, be withdrawn and that the revised specifications submitted herewith be substituted; that the specifications for salt to be used in regeneration of zeolite water softening plants be approved for inclusion in the Manual.

(2) Cause and extent of pitting and corrosion of locomotive boiler tubes and sheets (Appendix B). It is recommended that the report be received as information and the subject continued.

(3) Methods and value of water treatment with respect to small plants for feeding compounds, sodium aluminate, soda-ash, or other chemicals into boilers or roadside tanks (Appendix C). It is recommended that the report be received as information and the subject continued.

(4) Schedules for washouts, water changes and blow-down of locomotive boilers, as influenced by water conditions (Appendix D). It is recommended that the report be received as information and the subject discontinued.

(7) Application, comparative economy, and effectiveness of various coagulants used in softening and clarifying waters for use in locomotive boilers (Appendix E). It is recommended that the report be received as information and the subject discontinued.

(10) Advisability of standardizing valves and packing for water service pumps (Appendix F). It is recommended that the report be received as information and the subject discontinued.

Bulletin 342, December, 1931.

Progress is reported on the following subjects:

(5) Development of deep well pumping equipment.

(6) Design and maintenance of track pans for locomotive water supply.

(8) Progress being made by Federal and State Authorities on regulations pertaining to railway sanitation, collaborating with the Joint Committee on Railway Sanitation, A.R.A.

(9) Sewage disposal facilities when sanitary facilities are not available.

Respectfully submitted,

THE COMMITTEE ON WATER SERVICE AND SANITATION,

R. C. BARDWELL, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

R. C. Bardwell, Chairman, Sub-Committee; C. H. Fox, W. P. Hale, C. R. Knowles, L. A. Henry, W. B. McCaleb, H. L. McMullin, D. A. Steel, R. A. Tanner, F. P. Turner, J. C. Wallace, R. S. Wilson.

In discussing the influence of water quality on locomotive boiler operation, reference is frequently made to the terms "Pitting," "Grooving," and "Embrittlement." These terms describe distinctive definite phenomena but are sometimes used interchangeably by uninformed and it is therefore considered advisable to include definitions of the meaning in the list of definitions concerning railway water service. The definitions approved and recommended by your Committee for inclusion in the Manual are as follows:

GROOVING.—Localized corrosion in strained areas, occurring in well-defined lines such as long bends and around staybolts or bracing.

PITTING.—Localized corrosion occurring in spots which frequently penetrate the entire sheet of metal.

EMBRITTLEMENT.—Failure of boiler metal resulting from intercrystalline cracks.

WATER ANALYSIS

There has been some criticism of the Standard Methods of Water Analysis and Interpretation of Results, appearing on pages 921 to 925 inclusive of the 1929 Manual. It is admitted that the method as shown in the Manual is somewhat inadequate and subject to advisable correction.

This subject has been considered by various committees of other technical organizations during the past seven years and agreement has been reached covering changes which are deemed desirable and this subject will be covered in the new edition of the Standard Methods of Water Analysis, which is to be published at an early date under the auspices of the American Public Health Association and the American Water Works Association.

Your Committee has been represented at the meetings of the other technical associations and we wish to submit the following recommended changes which are in agreement with the methods approved by other technical organizations with the one exception of "reporting the analyses in terms of—grains per U.S. Gallon, instead of parts per million." It is recommended that the following outline of water analysis replace the methods shown on pages 921 to 925 inclusive of the 1929 Manual.

STANDARD METHODS OF WATER ANALYSIS AND INTERPRETATION OF RESULTS

General

The general practice for reporting water analyses is in terms of grains per U.S. gallon, which is equivalent to parts per 58,341. This appears to convey a clear impression of the actual condition of the water, which is the ultimate purpose of the analysis, and it is recommended that reports of water analysis in grains per gallon with supplementary advice as to pounds per thousand gallons of total incrustants, total non-incrustants, and total solids, be adopted as standard practice.

If reports are desired in terms of grains per Imperial gallon, which is equivalent to parts per 70,000, direct readings can be made from the same standard solutions outlined below by using 70 ml. samples of the water to be examined instead of 58.3 ml. as specified. Likewise, if reports are desired in parts per 100,000 direct readings can be made from same standard solutions by using 100 ml. sample instead of 58.3 ml.

Form and Combination

Although the actual determination of substances in water is usually made of the various elements or radicals direct, the customary and accepted practice for reporting results of water analysis is by hypothetical combinations of the radicals. The following method is recommended for uniformity: Silica—as found. Iron and aluminum oxides—as found (except in special cases of acidity where more extensive determination should be made). Make combination of positive radical determined, to negative radicals as found, in following order of sequence:

Positive Radicals	*Negative Radicals*
Calcium	Hydroxide
Magnesium	Carbonate
Sodium	Sulfate
Potassium	Chloride
	Nitrate

The standard form of report for water analysis will then be as follows:

	Grains Per Gallon
Calcium Hydroxide	....
Calcium Carbonate	....
Magnesium Carbonate	....
Calcium Sulfate	....
Calcium Chloride	....
Magnesium Chloride	....
Iron and Aluminum Oxides	....
Silica	....
Total Dissolved Incrusting Solids	————
Alkali Hydroxides	....
Alkali Carbonates	....
Alkali Chlorides	....
Alkali Sulphates	....
Organic and Undetermined	....
Total Dissolved Non-Incrusting Solids	————
Total Dissolved Solids	————

Interpretation

Incrustants.—The silica, iron and aluminum oxides, and the calcium and magnesium combinations will be classed as incrusting solids.

Non-Incrustants.—The sodium, alkali salt combinations, and organic matter will be classed as non-incrusting solids.

Corrosive.—All acids, iron and aluminum sulfate, calcium chloride and nitrates, magnesium sulfate (in appreciable amounts), chloride, and nitrate will be classed as corrosive salts.

FIELD SURVEY OR RAPID CHECK TESTS

Field survey tests for boiler waters are generally confined to a means of approximating the total hardness or total amount of scale forming matter, and the division of this figure into the alkalinity (carbonate hardness) and the non-carbonate hardness, as well as an approximation of the ratio of the calcium and magnesium salts. With experience in manipulation, the following procedure can be made to give close and very satisfactory results:

Reagents

1. Standard Calcium Chloride Solution.—Dissolve 0.5 grams of pure calcite (calcium carbonate) in a little diluted hydrochloric acid, being careful to avoid splattering. Wash down and neutralize with ammonium hydroxide to slight alkalinity, litmus paper indicator. Make up to 500 ml. with carbon dioxide free distilled water and store in glass-stoppered bottle. One ml. of this solution is equivalent to 1.0 mg. calcium carbonate.

2. Standard Soap Solution.—Make up stock solution by shaking vigorously, approximately 100 grams of powdered castile soap or sodium oleate in one liter of 80 per cent grain alcohol and allow to stand at least 12 hours. Dilute the clear supernatant liquid with 70 per cent grain alcohol until 1.0 ml. is equivalent to 1.0 ml. of the standard calcium chloride solution making due and recorded allowance for a lather factor which will vary from 0.7 to 1.4 ml. with different soaps. One ml. of this solution is equivalent to 1.0 mg. calcium carbonate.

3. N/50 Sulfuric Acid.
4. N/50 Sodium Carbonate.
5. Phenolphthalein indicator.
6. Methyl Orange indicator.

Procedure

1. Total Hardness.—Measure 58.3 ml. of the water to be examined into an 8-ounce bottle. Add the standard soap solution in small amounts at a time, shaking vigorously after each addition, until a strong permanent lather is secured which will stand for five minutes. It is usually satisfactory to add amount of soap solution equal to the lather factor as the first addition and then, as the end point is approached, to cut the additions of soap solution to 0.1 ml. or more depending upon the accuracy desired and the experience of the manipulator. Note and record any false end point which is the dividing line between the calcium and magnesium salts. The final burette reading after deducting the lather factor, gives the total hardness ("H") in terms of calcium carbonate as grains per gallon. (In determining the hardness of acid waters they should first be rendered neutral to methyl orange by addition of N/50 sodium carbonate solution.

Samples containing appreciable amounts of free carbon dioxide should be neutralized to faint pink with N/50 normal sodium carbonate solution before testing). The difference between the false end point and the total hardness indicates the amount of magnesium salts, the balance being calcium salts, all, expressed as grains per gallon in terms of calcium carbonate. If the hardness test requires more than 15.0 ml. of soap solution, it is best to take an aliquot portion and dilute to 58.3 ml. with carbon dioxide free distilled water so that the final lather point will be less than 15.0 ml. After deduction of the lather factor multiply the result accordingly to obtain correct hardness value.

To avoid mistaking the false or magnesium end-point for the true one when adding the soap solution to waters containing magnesium salts read the burette after the titration is apparently finished and add about 0.5 ml. more of soap solution. If the end-point was due to magnesium the lather will disappear. Soap solution must then be added until the true end-point is reached. Usually the false lather persists for less than five minutes.

2. Alkalinity.—Titrate 58.3 ml. of the water under investigation with N/50 sulfuric acid solution, using methyl orange indicator. The number of milliliters of N/50 sulfuric acid used, gives the alkalinity ("A") or carbonate hardness plus any causticity, directly as grains per gallon in terms of calcium carbonate.

In case of alkaline waters, if the total hardness is greater than the alkalinity, the difference between the two represents the non-carbonate hardness. If the total hardness is less than the alkalinity, the difference is sodium carbonate, all of the hardness being then in the form of carbonate hardness. In case of acid waters, all of the hardness will be non-carbonate hardness.

3. Negative Alkalinity.—In case the water under investigation is acid to methyl orange indicator, titrate 58.3 ml. sample with N/50 sodium carbonate solution, using methyl orange indicator. The negative alkalinity (or acidity) is obtained directly as grains per gallon in terms of calcium carbonate.

4. Tests on Treated Waters.—When the water under investigation is a lime-soda-ash treated water, titrate 58.3 ml. of the water with N/50 sulfuric acid solution, using phenolphthalein indicator. Multiply the reading by 2.0 and record as "causticity modulus" ("C").

Add methyl orange indicator to the colorless solution and continue the titration with N/50 sulfuric acid solution, recording the final reading (that is, the sum of the phenolphthalein and methyl orange requirements) as "alkalinity" ("A").

The determination of the hardness ("H") of the water is made as outlined above.

The difference between the hardness ("H") and the alkalinity ("A") shows a presence of soda-ash if the alkalinity ("A") is in excess, or an absence of soda-ash if the hardness ("H") is in excess, all directly as grains per gallon in terms of calcium carbonate. Likewise, excess of the causticity modulus ("C") over the alkalinity ("A") indicates the presence of lime or caustic soda, while an excess of alkalinity ("A") over causticity modulus ("C") shows an absence of soda-ash, either being reported directly as grains per gallon in terms of calcium carbonate. In other words, this difference shows the amount of the excess or deficiency of hydrate alkalinity.

RAPID LABORATORY METHODS

The following methods may be used for routine laboratory procedure where it is desired to obtain quick results of accuracy sufficient to differentiate between constituents normally presented in water, and to furnish sufficient information for making an ordi-

nary analytical report which will permit a judgment to be made as to the general effect of the quality of the water examined for boiler use.

Reagents

1. Standard soap solution. See Field Survey.
2. N/50 sulfuric acid solution.
3. N/50 sodium carbonate solution.
4. N/20 soda reagent. Prepared by mixing equal volume of solutions of N/20 sodium carbonate and N/20 sodium hydroxide. (Note.—The soda reagent used in sanitary water analysis is of N/10 strength).
5. STANDARD SODIUM CHLORIDE SOLUTION.—Dissolve 1 g. of pure sodium chloride in one liter of distilled water. One ml. is equivalent to one mg. NaCl.
6. STANDARD SILVER NITRATE SOLUTION.—Weigh about 2.906 g. of silver nitrate and dissolve in one liter of distilled water. Adjust so that 1 ml. of this solution is equivalent to 1 ml. of standard sodium chloride solution (solution No. 5). One ml. is equivalent to 1 mg. NaCl.
7. Phenolphthalein indicator.
8. Methyl orange indicator.
9. Potassium chromate indicator.
10. Saturated lime water, prepared by shaking excess of CP hydrated lime with distilled water, let settle, and using the clear supernatant liquid.

Procedure

1. TOTAL DISSOLVED SOLIDS.—Evaporate 58.3 ml. of the water under investigation (filtered, if necessary) to dryness in a weighed dish and heat the residue for one hour at 180 degrees Centigrade. Cool in dessicator and weigh. The number of milligrams will give total solids direct as grains per gallon.

2. ALKALINITY.—Titrate 58.3 ml. of the water under examination with N/50 sulfuric acid, methyl orange indicator, which gives grains per gallon directly of bicarbonate, carbonate and hydrate alkalinity, expressed in terms of calcium carbonate, $CaCO_3$. (Note—If lime and soda-ash treated water, or a boiler sample is under examination, the causticity modulus and alkalinity should be determined as outlined under "4", "Rapid Check Test" and report made accordingly.)

3. TOTAL HARDNESS.—The approximation of the total hardness for comparative purposes should be made with soap test as outlined under No. "1", "Rapid Check Tests."

4. NON-CARBONATE HARDNESS.—Boil 116.7 ml. of the water under examination in a 250 ml. Erlenmeyer flask for at least 15 minutes. From the results of hardness test, calculate the amount of soda reagent which will be necessary and add at least 10 ml. of the reagent in excess (usually 25 ml. is sufficient). Boil at least 10 minutes additional. Transfer to a 200 ml. graduated flask, cool, and make up to the mark with carbon dioxide free distilled water. Filter off 100 ml. and titrate the filtrate with N/50 sulfuric acid solution using methyl orange indicator. A blank should be run with 116.7 ml. of the distilled water, the same amount of soda reagent, and the same treatment. The difference in the amount of N/50 sulfuric acid solution required for neutralizing 100 ml. of the blank and 100 ml. of the sample gives the non-carbonate hardness directly as grains per gallon in terms in calcium carbonate. If the difference is negative it reveals the presence of sodium carbonate, or sodium hydroxide in amount expressed as grains per gallon in terms of calcium carbonate.

5. MAGNESIUM.—Take 116.7 ml. of the water under examination in a 250 ml. Erlenmeyer flask and exactly neutralize to methyl orange indicator, using N/50 sulfuric acid solution. Boil 15 minutes to expel all free carbon dioxide and add a solution of saturated lime water, so that, as shown by the hardness test, there will be at least 10 ml. in excess (usually 25 ml. is sufficient). Continue boiling for at least 10 minutes. Transfer to a 200 ml. volumetric flask, cool, and make up to volume with carbon dioxide free distilled water. Filter and titrate 100 ml. with N/50 sulfuric acid solution, using methyl orange indicator. Run a blank determination at the same time, using 116.7 ml. of distilled water and the same treatment with the same amount of saturated lime water. The difference between the amount of N/50 sulfuric acid solution required for neutralizing 100 ml. of the blank and 100 ml. of the sample gives the magnesium compounds present as grains per gallon in terms of calcium carbonate. (Note.—If iron or aluminum salts are present in appreciable amount, they should be removed before applying this method).

6. SODIUM CHLORIDE.—Titrate 58.3 ml. of the water under examination with standard silver nitrate solution, using potassium chromate indicator. The result gives chloride directly in terms of grains per gallon NaCl.

7. SILICA-IRON ALUMINUM.—If it appears that the silica-iron aluminum content is in excess of 1.0 grains per gallon, it may be well to separate and weigh by the usual gravimetric methods. For rapid determination of iron, the colorimetric method for total iron may be used and the aluminum can be determined by difference.

8. SULFATE.—There is ordinarily little necessity for making this determination in the boiler water analysis as the difference between total solid content and the calculated constituents can be taken to be non-incrusting sulfates. If organic matter and nitrates appear high, the gravimetric determination as a barium sulfate may be made, or the turbidimetric method of Muer or the Parr sulphophotometer method may be used.

Reporting of Results

The following method can be used in calculating hypothetical combinations in the average waters:

(a) In making final report, compare results for non-carbonate hardness and magnesium. If the non-carbonate hardness is in excess of the magnesium, calculate the magnesium to magnesium sulfate. Calculate the remainder of the non-carbonate hardness to calcium sulfate. The alkalinity is then to be reported as due entirely to calcium carbonate.

(b) If the non-carbonate hardness is less than the magnesium, calculate the non-carbonate hardness to magnesium sulfate and the balance of the magnesium to magnesium carbonate. The magnesium carbonate is subtracted from the value for alkalinity. The difference between the alkalinity and the magnesium carbonate is then reported as calcium carbonate.

(c) If the non-carbonate hardness is negative, make proper allowance in the alkalinity value for sodium carbonate, calculate the magnesium to magnesium carbonate, making further allowance in the alkalinity value, and the balance of the alkalinity is calcium carbonate.

(d) The difference between the total solids and the sum of magnesium sulfate, magnesium carbonate, calcium sulfate, calcium carbonate, sodium chloride, sodium carbonate, iron and aluminum oxides, and silica, gives the amount of non-incrusting sulfates, nitrates and organic matter. There is ordinarily no necessity for separating the last three

constituents in ordinary boiler water analysis unless, after heating the residue from total solids, a black discoloration is noted, indicating a high organic content which might induce foaming in the boiler.

(Note.—If the above difference is negative, the result indicates calcium and magnesium chlorides or nitrates in which case it will be necessary to make the sulfate determination in order to secure the most probable hypothetical combination.)

Additional Methods

1. Calcium.—To 116.7 ml. of water add 10 ml. of saturated solution of ammonium chloride and 1 ml. of ammonium hydroxide solution (1.1). Precipitate the calcium by adding the saturated solution of recrystallized oxalic acid until a faintly acid reaction is obtained as determined by litmus or by the absence of odor of ammonia. It is preferable to add one-half of the oxalic acid first and rotate vigorously before bringing the final acid reaction. Add 5 ml. of a saturated solution of ammonium oxalate, boil vigorously for 15 minutes, or heat for one or two hours on a steam bath with a beaker surrounded by live steam, and then filter on asbestos in a platinum Gooch crucible previously ignited but not weighed. Wash the beaker four or five times with hot water from top to bottom, decanting into the crucible each time. Wash the crucible down once or twice, remove and wash down from the outside. The total wash water is usually between 35 and 50 ml. Do not clean the beaker with a policeman, but place the crucible in the beaker. Add boiling water sufficient to cover the crucible. Add 10 ml. of sulfuric acid (1.1) and titrate the oxalic acid produced by the reaction of the sulfuric acid on the precipitate with N/25 potassium permanganate solution. Subtract 0.1 ml. for a blank. Each ml. of N/25 permanganate solution used will equal 1.0 grains per gallon of calcium in terms of calcium carbonate.

2. Nitrates.—Use phenoldisulfonic acid method, as employed in sanitary water analysis—Sec. XI A.P.H.A. Standard Methods.

3. Carbon Dioxide.—Titrate 58.3 mil. of the sample with N/50 sodium carbonate solution, using phenolphthalein indicator. Result in ml. will give grains per gallon in terms of calcium carbonate.

FULL AND COMPLETE LABORATORY EXAMINATION

For full and complete examination of boiler waters as may be required in special cases, it is recommended that the procedure be used as outlined in the latest edition of "Standard Methods of Water Analysis" published by the American Public Health Association, 370 Seventh Avenue, New York City, in collaboration with the American Water Works Association and the American Chemical Society, which have been universally accepted as standard.

SALT SPECIFICATIONS

During the past few years, there has been an appreciable increase in the number of zeolite water treating plants installed for railway service. These plants require the use of salt (sodium chloride) for regeneration.

A special grade of salt is required for this purpose which will contain the necessary sodium chloride and be of such physical property that will not pack. There have been no suitable specifications available for railroads to use in the purchase of this ma-

terial. Specifications are given in our Manual for other chemicals used in water softening and in view of the considerable increase in the use of this material, it is believed that specifications for salt should likewise be included.

The following is given as the recommendation of your Committee for publication in the Manual.

SPECIFICATIONS FOR SALT TO BE USED IN REGENERATION OF ZEOLITE WATER SOFTENING PLANTS

Definition

1. Salt for use in the regeneration of zeolite water softening plants shall be sodium chloride, commercially known as common salt.

Classes

2. Either Crushed Rock Salt or Evaporated Salt will be acceptable, provided they meet the physical and chemical requirements.

(I) Chemical Properties and Tests

Sampling

3. The sample shall be a fair average of the shipment. A one pound sample shall be taken from various locations in each carload or less and forwarded to laboratory named by purchaser. Sample shall be kept in air-tight container and the unused portion shall be stored until the shipment has been finally accepted or rejected by the purchaser.

Check tests on samples taken from cars at their destination will occassionally be made, and should agree within reasonable limits with the initial sample.

Chemical Properties

4 (a). The chemical properties of the salt sample shall be determined by standard methods of chemical analysis.

(b). Water softener salt shall conform to the following requirements as to chemical composition:

Sodium chloride—98.0 per cent minimum.

(II) Physical Properties and Tests

5. The material shall be in a dry granular form and shall be free from lint, chips, trash, and other foreign matter.

Fineness

6. All particles must be of such size as to pass through a U.S. Bureau of Standards No. 2 sieve which has an opening approximately 0.5 inches square, and not more than 10 per cent shall be coarser than 3/8 inch. At least 90 per cent must be retained on a U.S. Bureau of Standards No. 10 sieve which has openings approximately 0.0787 inches square, or not more than 10 per cent finer than 1/16 inch.

(III) Packing and Marking

Packing

7. Water softener salt may be furnished in bulk if so ordered by purchaser or in paper or burlap sacks of not more than 100 lb. net weight.

Marking

8. When shipped in paper or burlap sacks, the weight shall be plainly marked on each package, together with the name of manufacturer.

(IV) Inspection, Penalization and Rejection

Inspection

9 (a). All water softener salt shall be subject to inspection.

(b). The salt may be inspected at the place of manufacture or the point of delivery, as arranged at time of purchase.

(c). The purchaser may make the tests to govern the acceptance or rejection of the salt in his own laboratory or elsewhere as designated. Such tests shall be made at the expense of the purchaser.

Penalization

10. All prices shall be based upon furnishing the percentage of sodium chloride specified. If a lower grade is furnished, provided it is not less than 95 per cent sodium chloride, it may be accepted by the purchaser upon the vendor making a rebate equal to the percentage of sodium chloride below the minimum designated.

Water softener salt below 95 per cent sodium chloride will be rejected.

Rejection

11 (a). Unless otherwise specified, any rejection based on failure to pass tests prescribed in this specification shall be reported within 10 working days of the taking or receipt of samples by the purchaser.

(b). Rejected salt shall be returned to the shipper or as he may direct. All freight charges in both directions to be paid by the shipper.

Rehearing

12. Samples which represent rejected salt shall be preserved in air-tight containers for 10 working days from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

Appendix B

(2) PROGRESS REPORT UPON THE CAUSE AND EXTENT OF PITTING AND CORROSION OF LOCOMOTIVE BOILER TUBES AND SHEETS, GIVING CONSIDERATION TO QUALITY OF WATER, CHARACTER OF METALS, METHOD OF MANUFACTURE AND TYPES OF BOILER CONSTRUCTION

J. H. Davidson, Chairman, Sub-Committee; W. M. Barr, R. E. Coughlan, B. W. DeGeer, J. H. Gibboney, E. M. Grime, J. R. Hickox, C. H. Koyl, P. M. LaBach, J. J. Laudig, W. B. Nissly, O. T. Rees, R. M. Stimmel, C. P. VanGundy, J. B. Wesley.

Since there have been no outstanding developments in the theoretical aspects of this problem during the past year and no new methods of merit proposed for inhibiting pitting and corrosion, your Sub-Committee this year has confined its work to summarizing results of practical service tests of various methods of prevention which have been tried out during the past five years.

Information obtained from representative railroads operating in different sections of the country indicates that the most universally used method for preventing pitting and corrosion is that of maintaining sufficient caustic alkalinity in the boiler at all times.

This method is based on the electrolytic theory of corrosion which has been generally accepted as explaining practically all underwater corrosion with the exception of that caused by direct chemical action. This theory has been fully explained in a previous report of this Committee (see pages 493–495, Volume 23, Proceedings for 1922).

The degree of caustic alkalinity necessary to be carried in the boiler to provide this protective action depends upon several factors, such as the total amount and character of dissolved solids in the water and quantities of dissolved oxygen. Therefore it is impossible to give a definite value for the amount of caustic alkalinity necessary to inhibit pitting and corrosion in all types of boiler water. In general, if a pH value of 10 or more be maintained in the boiler feed water, this will be sufficient. But in special cases it will be found necessary to increase the amount of caustic alkalinity.

Therefore it can be readily seen that the success of this method depends on continuous and careful regulation of water treatment. The lack of a reliable method for determining the pH value of water under boiler working conditions is the chief handicap now encountered in the application of this method of treatment.

One feature which has probably made this method of inhibiting pitting and corrosion more generally used than any other so far advanced, is that the maintenance of the proper causticity also provides for the elimination of scale forming materials in the boiler water.

Recent developments in the study of the so-called embrittlement of boilers which has been attributed to excessive stresses in the material of the boiler combined with high caustic alkalinity in the boiler feed water have shown that several substances such as tannates, phosphates, chromates, nitrates, acetates, etc., as well as sodium sulphate will inhibit the embrittlement action of caustic soda, if present in proper amounts. It has also been demonstrated that undecomposed sodium carbonate is of assistance in this respect.

When these factors are given due consideration and the alkalinity and causticity of the boiler water is accurately determined by approved methods, many feedwaters which have previously been considered of a quality that might possibly promote embrittlement, will be found to be well on the safe side in this respect.

For further details on this subject reference is made to Bulletin 216, of the Engineering Experiment Station of the University of Illinois.

Several very favorable reports of success with the counterelectric potential method with the use of arsenic compounds for inhibiting corrosion have been received by the Committee. Where conditions are such that it is not desirable or practical to maintain sufficient caustic alkalinity as referred to above or when water not requiring treatment for removal of scale forming materials is encountered, this method may be advantageously used.

It is a well-recognized fact that the removal of oxygen from the feedwater has been very beneficial in reducing pitting and corrosion in stationary boilers. While it is a comparatively simple matter to accomplish the removal of oxygen by deareators in connection with stationary boiler installations, it is exceedingly difficult to accomplish this in handling locomotive boiler feedwater. Open feedwater heaters where properly operated will remove sufficient oxygen to greatly retard pitting. However, unless special care and attention is given to the operation of open feedwater heaters, they cannot be depended upon to eliminate pitting and corrosion.

A great many service tests have been made with tubes and sheets of special metals and alloys recommended as resisting corrosion. The consensus of opinion of those who have furnished information concerning these tests is that at the present time the increased cost of these materials and in some cases difficulty in working them as compared with steel commonly used for this purpose is not justified by the results obtained.

Among other methods for preventing pitting and corrosion that have been suggested may be mentioned, use of metallic or other protective coatings applied directly to tubes and sheets; use of substances in the feedwater which form protective films, and devices intended to increase circulation of water in the boilers. None of these methods have been used extensively enough to warrant any conclusions to be drawn concerning their effectiveness.

Attention is called to report of Sub-Committee 11—"Protection of Boilers and Boiler Materials from Corrosion and Deterioration While in Storage," which appears on pages 422–428 of Vol. 32, Proceedings for 1931. This describes in detail damage sustained by locomotive boilers during storage periods and suggests as one possible preventative of this damage the blowing of soda-ash into the boiler so as to coat all interior surfaces after the water has been drained out.

One road which has had considerable trouble due to moist salt air, corroding engines in storage, reports storage to a maximum of four years with no observed pitting by employing the following method:

"The boiler is washed preliminary to storing, filled completely with water, on which 10 gallons of fuel oil is floated. The water is then drained out slowly and the engine stored with washout plugs removed."

Another road recommends the following:

"Fire locomotives up with boiler full of water to maximum steam pressure. Blow out water and steam, raise dome cap, permitting evaporation from the highest point. When taken to storage track, handle engine in reverse position blowing moisture out of superheat units and water legs. Fill the boiler up to the dome with neutral paraffin base crude oil. Drain the oil out and close all openings."

Much progress has been made in arresting pitting and corrosion in locomotive boilers since this subject was first assigned to your Committee for study in 1922.

The question of corrosion and its prevention must be considered as an economic problem. Therefore the cost of any method of prevention must be compared with the loss due directly or indirectly to deterioration.

Experimental work should be continued and every effort made to perfect methods which give promise of an economic solution of the problem.

Appendix C

(3) METHODS AND VALUE OF WATER TREATMENT WITH RESPECT TO SMALL PLANTS FOR FEEDING COMPOUNDS, SODIUM ALUMINATE, SODA-ASH, OR OTHER CHEMICALS INTO BOILERS OR ROADSIDE TANKS

C. H. Koyl, Chairman, Sub-Committee; W. M. Barr, R. W. Chorley, R. E. Coughlan, W. L. Curtiss, L. E. Elliott, J. H. Gibboney, J. P. Hanley, J. R. Hickox, R. L. Holmes, H. F. King, H. L. McMullin, S. B. Mitchell, R. M. Stimmel, R. S. Wilson.

Last year this Committee endeavored to establish the principles and provide the data from which might be determined in individual cases whether a natural water should be used as locomotive feedwater (1) without any treatment, (2) with merely the intro-

duction of suitable chemicals into the water in the roadside tank or the engine tank, or (3) should be treated in an independent wayside plant with lime and soda, or whatever chemicals were necessary to soften and put it into good boiler condition.

(1) It was stated as our belief that "few natural waters are so good that some form of treatment does not improve them", and that boilers are in best condition when the water in the boiler has a sodium alkalinity sufficient to inhibit scale and corrosion, which is never less than 3 grains per gallon and should always amount to 15 per cent of the total dissolved solids. With good natural waters, this usually means the addition of perhaps a half-pound of soda-ash, or its equivalent, to each thousand gallons of water put into the boiler.

(2) The above waters and the second class of waters, which are hard enough to cause scale and leaking in boilers but yet do not rank with the very bad waters, are commonly handled by what is called "interior treatment", not meaning that the boiler is treated in any way but merely that the water is treated with an amount and kind of chemical which will not precipitate scale matter in the cold but will do so when raised to the temperature of the boiler.

The chemicals for "interior" treatment cost as much as the chemicals for "complete" treatment, sometimes more, and the principal difference in expense between the two methods is the interest and depreciation on the cost of the plants.

In the first half of this report which was presented last year (Proceedings 1931, page 402) we stated the result of our experience that "complete" treating plants pay a reasonable return when treating 5000 gallons per day of water having a hardness of 8 grains per gallon, but below this amount of water daily *and* below a hardness of 8 grains per gallon it is usually more economical to provide only "interior" treatment. When, however, the 8 grains of hardness is mostly sulphate it is better to use "complete" treatment because the boiler will be likely to foam if the water carries not only the 8 grains of sodium sulphate but also the total precipitate. And there are several railroad water stations at which 8-grain water, not mostly sulphate, is wisely handled by "complete" treatment because the amount used per day is from one to five million gallons and in such quantity the advantage of water which is soft and clean as it enters the boiler is much more than the interest and depreciation on a "complete" treating plant.

Last year we called attention to the very important distinction between the possibility and the desirability of operating locomotive boilers with certain kinds of waters with "interior" treatment.

There is no dispute that for small amounts of water not exceeding a hardness of 8 grains per gallon it is usually cheaper and satisfactory to use "interior" treatment, and we call this the zone in which "interior" treatment is desirable.

There is no dispute that for waters of a hardness of 25 grains per gallon and over, the softening and separation of precipitate should be carried out in a "complete" treating plant. It is only on Divisions where the average water hardness is between 8 grains and 25 grains that the question arises whether "interior" treatment is possible, and, if so, desirable.

By the term "average hardness" we mean not necessarily the average hardness of the waters of the Division but the average hardness of the water that is used. When 75,000 gallons per day is taken from a low-hardness supply and 25,000 gallons per day from a high-hardness supply, the difference in method of reporting is important.

Among these waters of average hardness between 8 grains and 25 grains the question is "below what point is interior treatment possible for tonnage trains in fast main-line service, operated by ordinary engine crews and not by expert western crews who

have handled foaming boiler water all their lives, which trains are expected to go up-hill or down without foaming, without the use of anti-foam compound and without excessive blowing-down," and we take our answer from the Wabash Ry. where the waters are said to average 15 grains per gallon hardness and to be almost free from alkali salts, and where soda-ash added to water in the roadside tanks has been the only boiler treatment for several years.

The average hardness of the waters successfully handled by "interior" treatment by the Canadian National between Sarnia and Montreal is 13 grains per Imperial gallon, or less than 11 grains per U. S. gallon, and the alkali salts average about 3 grains per gallon.

Even with such waters the strict enforcement of a road blow-down schedule is necessary to successful operation, and experience shows that it requires much supervision and much patience.

It is with great hesitation that we set limits of hardness as determining when "interior" treatment is possible and when it is desirable, because hardness is only one of the factors which determines it. The above figures of 15 grains and 8 grains we believe to be approximately correct for waters low in alkali salts, used in an average locomotive boiler by an average crew. But a boiler with 18-inch vertical steam space between water surface and steam exit will carry much worse water than can a boiler of 11-inch steam space. Mud, oil and organic slimes in water affect materially its foaming qualities; and there is some further difference in waters which we are not yet able to explain, because on the same railroad and with other conditions approximately equal, the boilers on one Division foam always with an alkali concentration of 100 grains per gallon, on another Division at 180 grains, and on still another at 300 grains. There are a few waters of hardness between 15 grains and 25 grains which can be handled by "interior" treatment provided that all the above conditions are in their favor, but success should not be expected by the inexperienced.

(3) In connection with what is known as "complete treatment" with lime and soda-ash for very bad waters attention is called to the fact that some natural waters contain silica either in colloidal state or in solution which is not affected by ordinary processes of water softening, so that it has happened many times that water softened down to 2 grains per gallon, or less, has deposited in boilers a very troublesome scale which is found to consist, about half and half, of silica and entrained calcium carbonate.

At the meeting of the American Chemical Society in Indianapolis last March, C. H. Christman reported successful tests for removing silica from water by treatment with sodium aluminate, the process being the formation of calcium or magnesium-aluminum-silicate which settles out.

At one water station on the C. M. St. P. & P. R. R. where 30,000 gallons of Mississippi River water is treated per hour, there has always been trouble from this silica scale, but a carefully adjusted slight excess of sodium aluminate now removes the silica (.6 g. p. g.) from the water in the treating plant, down to .1 g. p. g., and the excess of alumina over silica in the water in the boiler effectively prevents silica scale.

In last year's report we cited various chemicals—soda-ash, tri-sodium phosphate, sodium aluminate and the tannin compounds—as in approved use for the purpose of "interior treatment". Of these, soda-ash is always used in sufficient amount to antidote the sulphate hardness, and the other sodium compounds to supply the excess alkalinity and expedite the precipitation so as to lessen the tendency to foam. The tannin compounds are used to prevent precipitation in the injector and connecting pipes.

When chemicals are fed to the engine tank on the road, or even to the boiler while in the roundhouse, there are possibilities of error due not only to lack of training but

sometimes to prejudice, and several methods are in successful use for making the delivery of chemical proportional to the delivery of water either to the roadside tank or to the boiler.

An early successful by-pass proportioning device has been in general use on the Wabash Railway for several years for adding soda-ash to the roadside tank at each water station. Fig. 1 and 2.

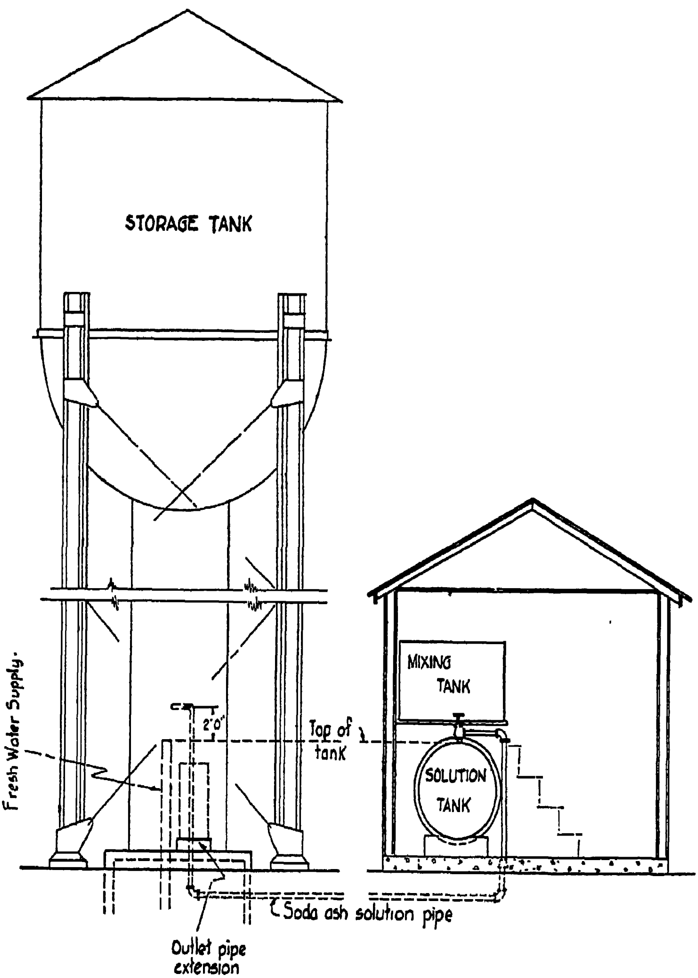


Fig. 1

Typical view showing connection of by-pass water storage tank.
(Wabash Railway)

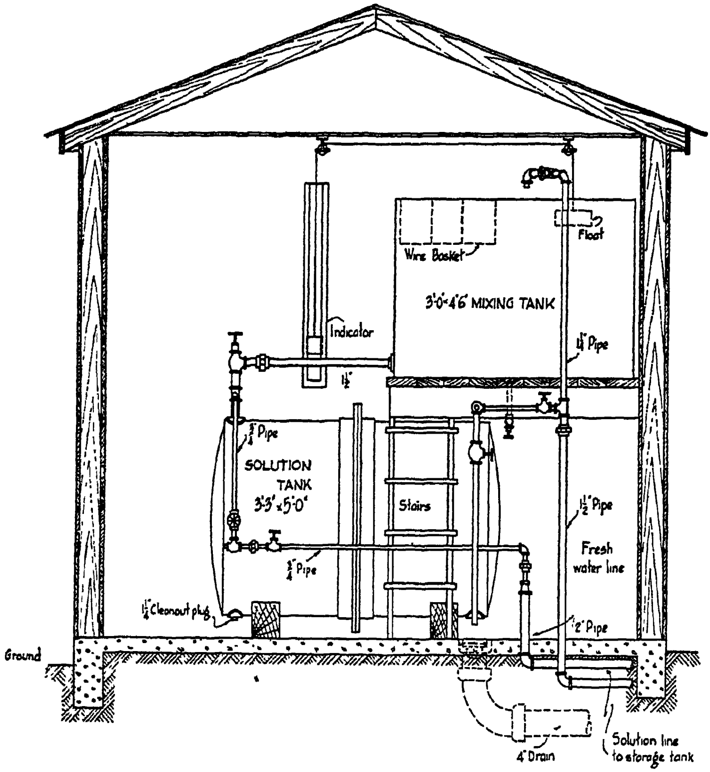


FIG. 2

Sectional view of soda-ash by-pass water treating system.
(Wabash Railway)

Another device for the purpose of adding compound to the water in the roadside tank has been used quite extensively on the Erie Railway for a long time. This feeder is connected to the water main serving the tank and a small amount of the water flow is diverted through the feeder, dissolving the chemical balls and carrying the solution into the water tank. These feeders are installed in pumphouses, frost-boxes or water meter pits. Fig. 3 and 4.

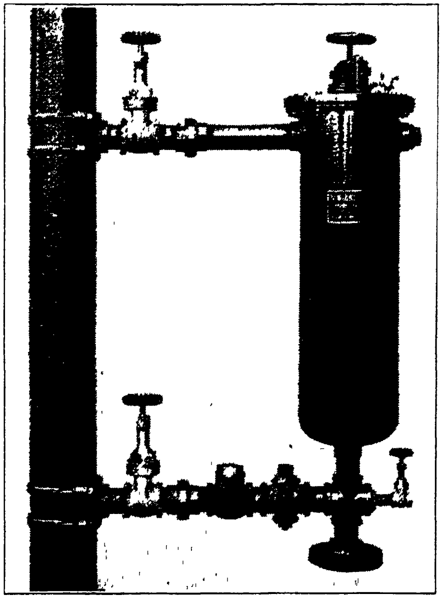


Fig. 3

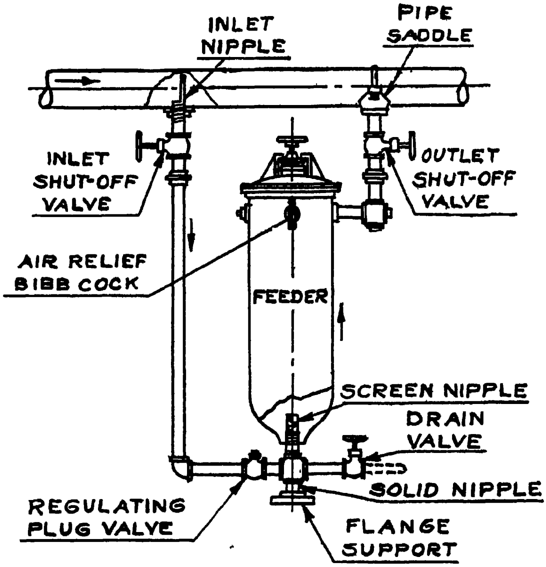
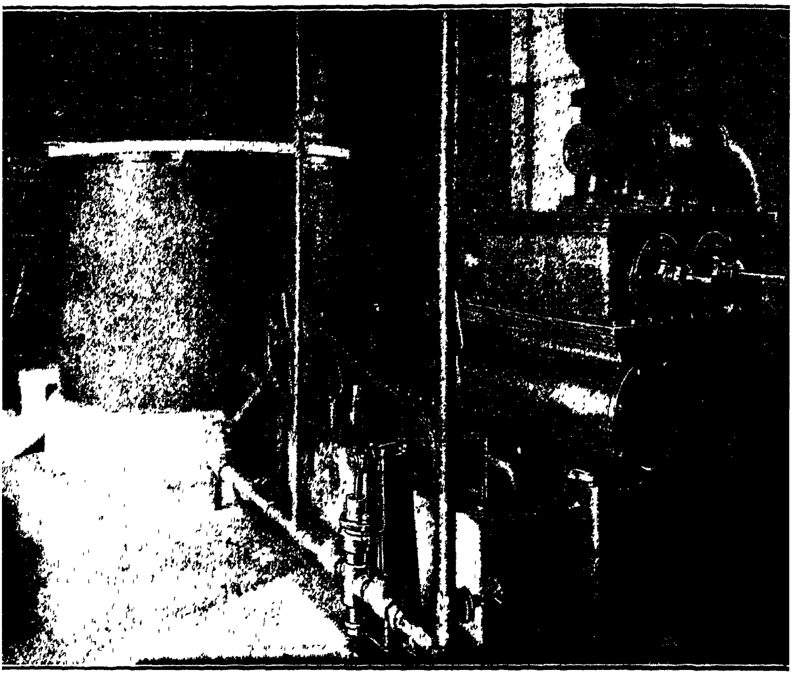

INLET
NIPPLE
PIPE
SADDLE
INLET
SHUT-OFF
VALVE
OUTLET
SHUT-OFF
VALVE
AIR RELIEF
BIBB COCK
FEEDER
SCREEN NIPPLE
DRAIN
VALVE
SOLID NIPPLE
REGULATING
PLUG VALVE
FLANGE
SUPPORT

Fig. 4

There are many small pumps for delivering dissolved chemical to the roadside tank, which are attached to and operated by the main water pump.

The next illustration shows a common form of water motor used for pumping chemical to the roadside tank in proportion to the amount of water which operates the motor. Fig. 5 and 6.



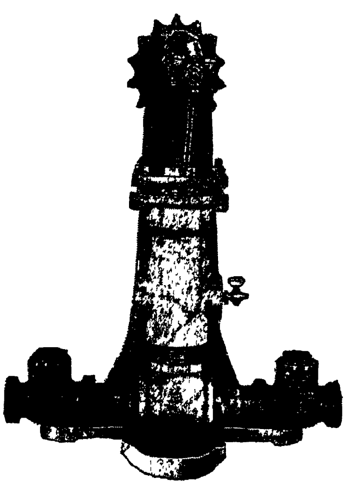


FIG. 5
A continuous chemical feeder

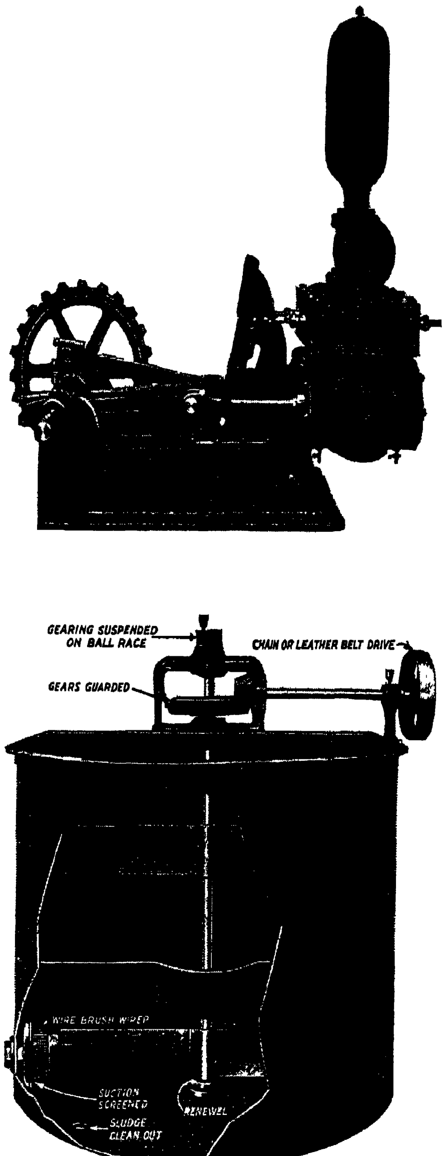


FIG. 6
A continuous chemical feeder.

The following illustrations show automatic methods for delivering sodium aluminate and its mixture to tanks and water columns. Fig. 7 and 8.

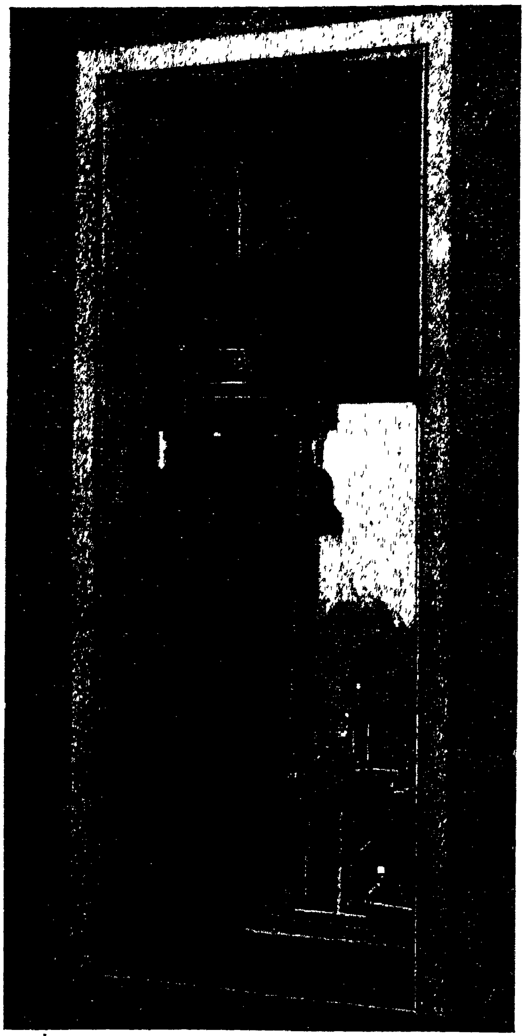


FIG. 7–a
Twelve inch water motor and proportioner installed in frost-box.

FIG. 7-b

Water motor installed in 12″ water main serving four water columns and driving proportioner. Motor and proportioner in concrete pit between tracks. Chemical vat in an adjacent house.

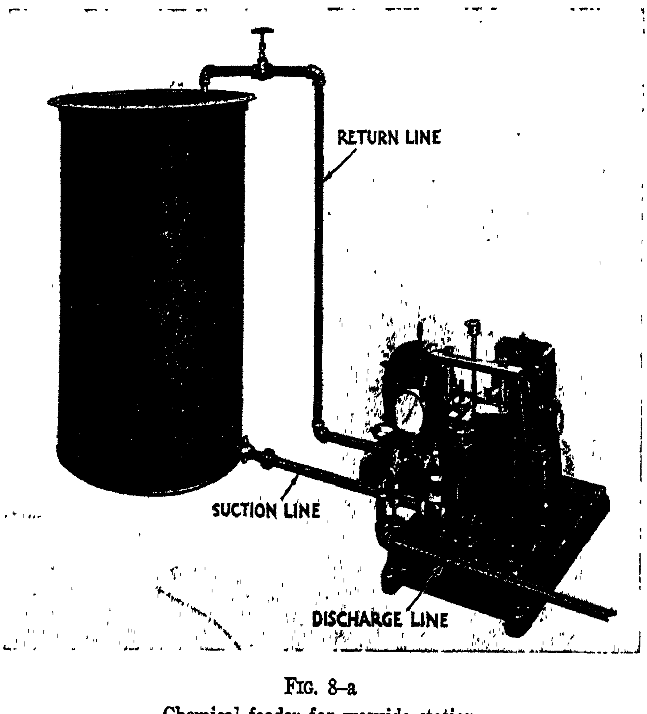


FIG. 8–a
Chemical feeder for wayside station.

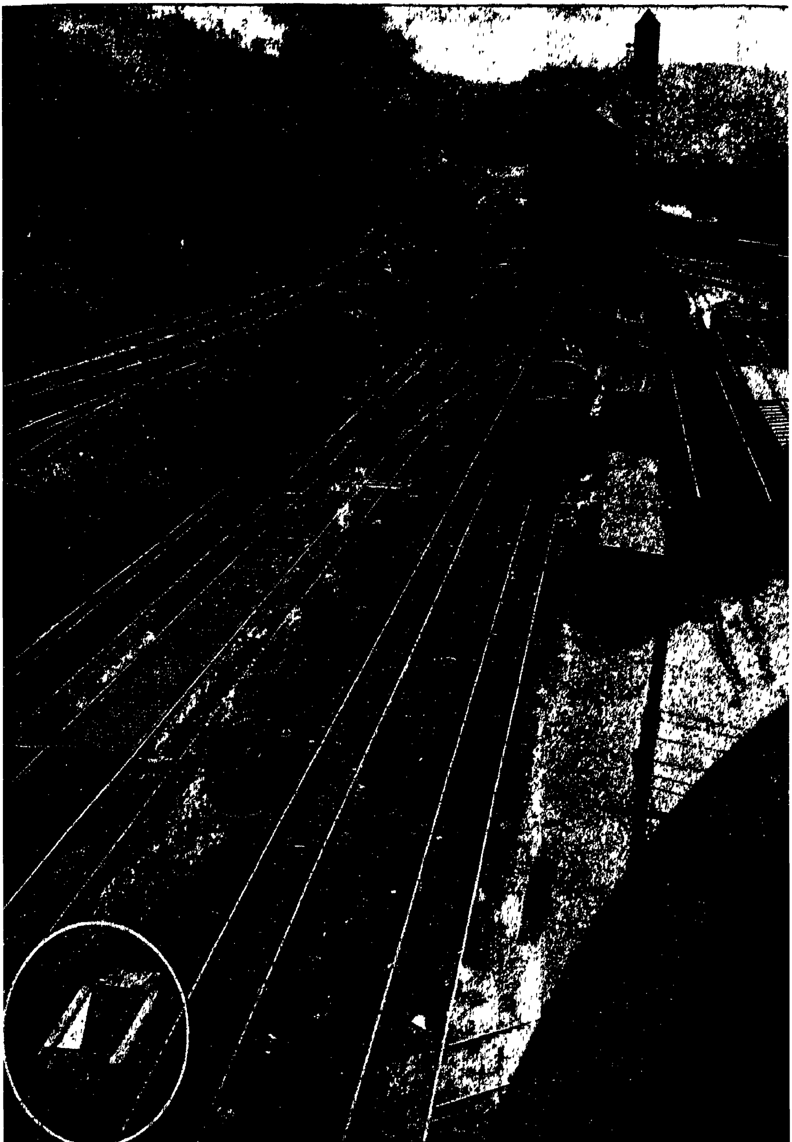
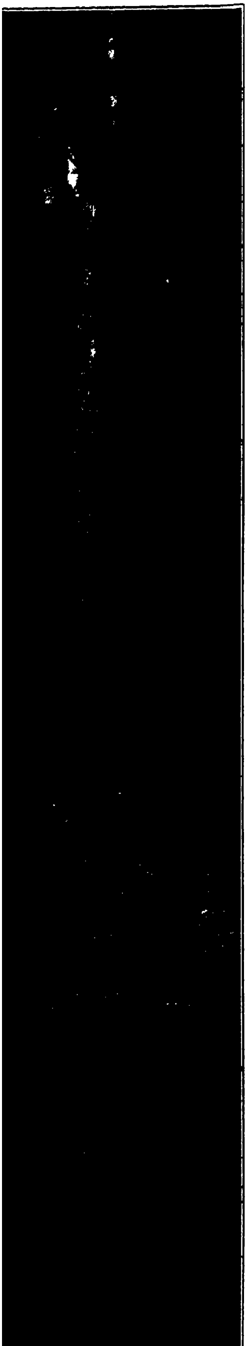


FIG. 8-b
View of yard from top of water tank showing pit (lower left) and the water columns served by this installation.



A fifth method, which treats only the water used in the boiler, has been used for five or six years on the Chicago & Northwestern Railway. This appliance consists of a container constructed around the locomotive branchpipe, between the injector and the boiler check, and connected with the water in the branchpipe by a single tube. The container is loaded and closed before each trip and the surging of the water in the branchpipe serves to add a small amount of compound to the water as it passes. One of the advantages of this style of feeding is that the injector is not affected by any tendency to early precipitation. There are some 400 to 500 of these appliances in successful use, and the only difficulty reported is due to leaky boiler check valves which permit hot boiler water to get into the branchpipe and clog it with too early precipitate. Fig. 9.

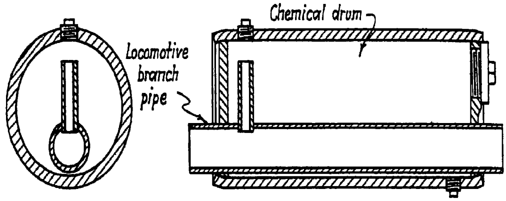


FIG. 9–b
Sectional view of regulator in place on feed water line.

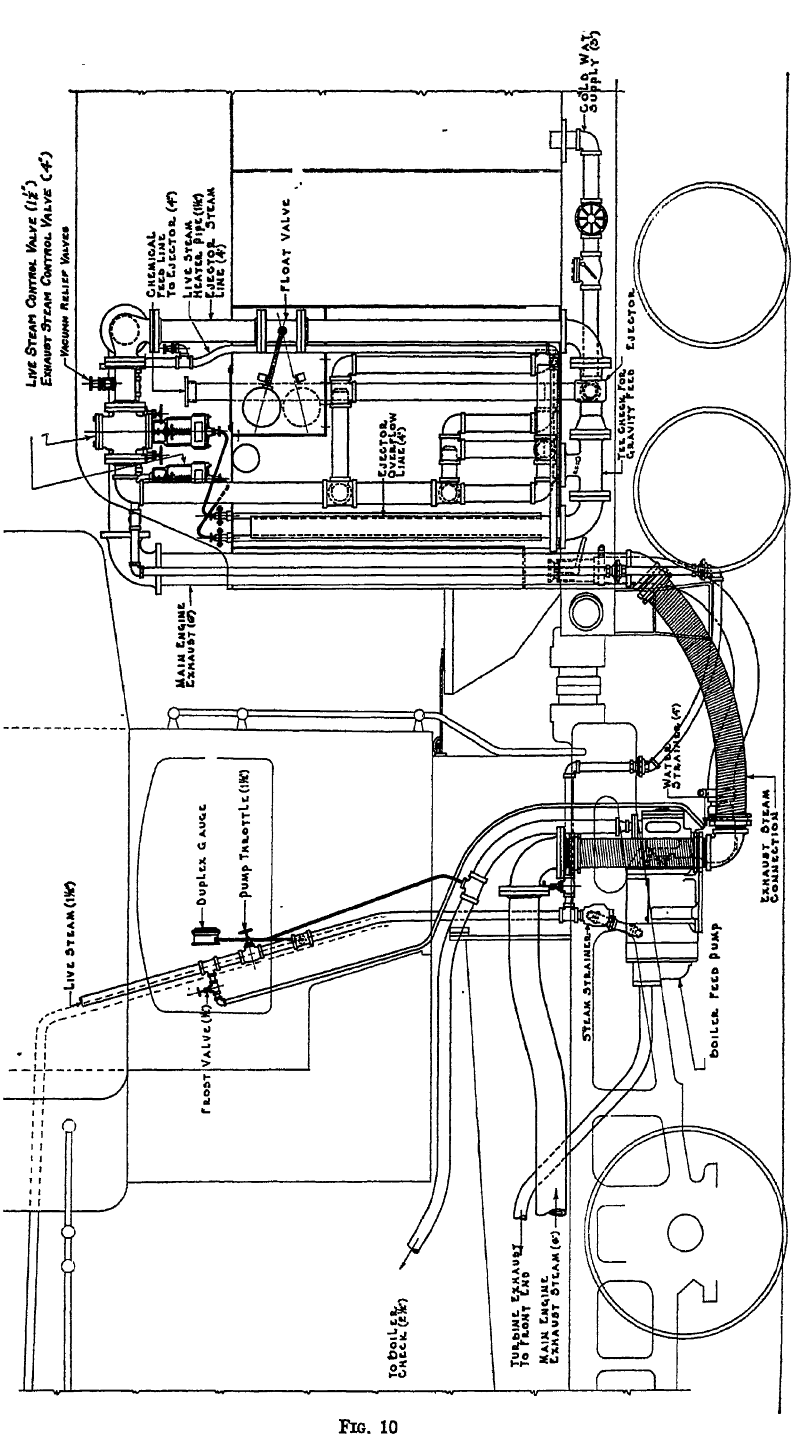


FIG. 10
Locomotive water conditioner. Typical installation.

A sixth appliance for this purpose is known as the Locomotive Water Conditioner. It is an open type feedwater heater with provision for the storage of 700 gallons of water heated to 210° by recovery of heat from the exhaust steam. The storage tank provides a means for the heat acceleration of any desired chemical reaction and means are provided for sludging out the precipitate before the water is pumped to the boiler.

This design of plant has the advantage of returning 10 per cent of distilled water to the engine tank and of removing more than 80 per cent of the oxygen dissolved in the cold water. Fig. 10.

The most important points to remember in connection with the use of interior boiler treatment are that the results should be subject to frequent chemical examination and that the best means of treating accurately is to regulate the supply by some one of the automatic appliances mentioned above. Nothing can take the place of careful constant supervision.

Appendix D

(4) WASHOUTS, WATER CHANGES, AND BLOW-DOWN OF LOCOMOTIVE BOILERS AS INFLUENCED BY WATER CONDITIONS

E. M. Grime, Chairman, Sub-Committee; W. R. Anthony, R. W. Chorley, R. E. Coughlan, L. E. Elliott, C. H. Fox, J. H. Gibboney, H. F. King, S. B. Mitchell, R. M. Stimmel, R. A. Tanner, J. B. Wesley.

One of the most important operating economies which has been accomplished during recent years has been that of the extension of locomotive runs from the former practice of about 100 miles per trip up to as much as 900 miles or more in some cases as is now found to be entirely practical. While these long runs have decreased the cost of boiler maintenance, they have increased the difficulties of operation as far as the engineman is concerned, at least to the extent that it is now necessary to watch the boiler water concentrations with more care and be certain that the power as it passes from one district to the next is kept continuously in good operating condition. Reliance is no longer placed on facilities located at 100-mile intervals where it was possible to drain or wash the boiler or attend to any deficiency which might have arisen on the trip and thus put this traveling power plant in proper shape for the next engineman. The responsibility for good operation is therefore shifted to a large extent from the terminal enginehouse forces to the engine crew.

Blow-Down Schedules

A proper schedule for boiler operation thus becomes of increasing importance as does also the proper training of the enginemen in a better understanding of water conditions. The methods adopted for locomotive boiler operation on any railway or district of a railway must depend to a large extent upon the various local conditions and more particularly upon the quality of the feedwater which is available. For satisfactory operation the first essential requirement is for dry steam at all times and under all pressures, and therefore the phenomenon known as "foaming" must not take place.

Foaming and Boiler Concentration

While experts may still disagree as to the exact cause of foaming, it is definitely known that a foaming condition is usually related to the kind and degree of concentration of total solids in the boiler water. The problem for the engine runner is therefore

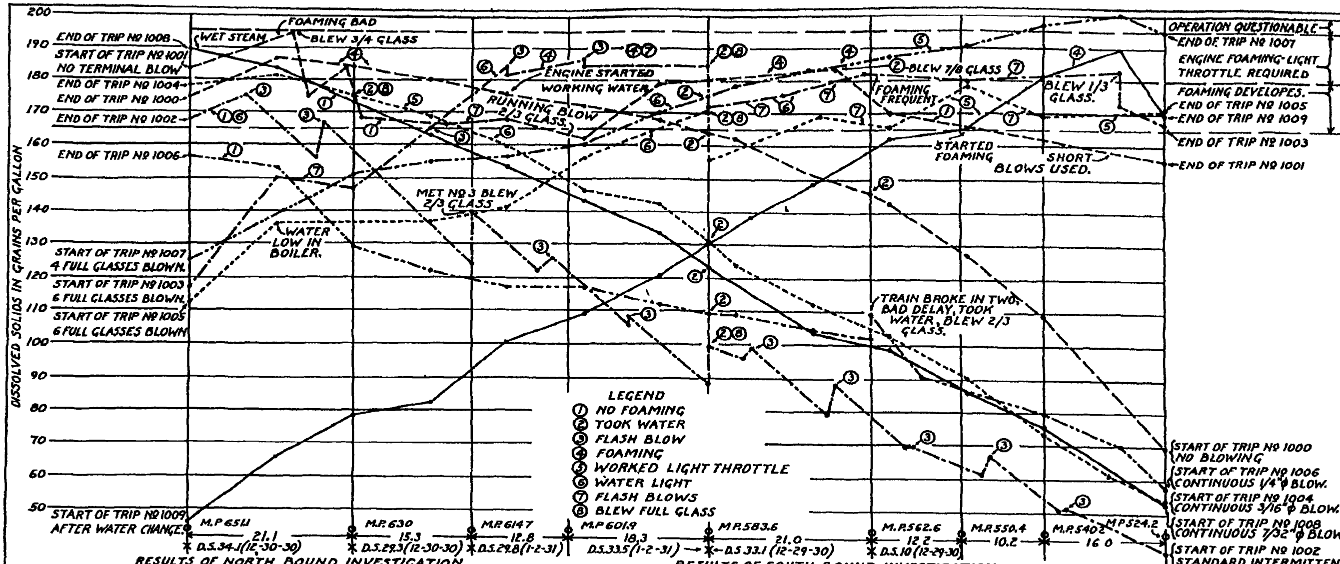
simple to the extent that he must so handle his boiler as to hold the total concentration of solids below the point where foaming will occur. In that excellent article on the effect of water treatment on locomotive operation appearing in the "Proceedings of the 35th Annual Convention of the Traveling Engineers' Association" the Committee summed up the disadvantages of water treatment under the one word "Foaming." They used the expression "Foaming, if permitted," adding the words "if permitted" because they felt that with proper organization and full understanding of the situation by enginemen and all who have anything to do with the handling of treated water, foaming can and should be avoided in practically all cases.

If the operation is in a section where the natural waters are soft and low in alkali salts or, say, below five grains per gallon total solids, the boiler water concentration may never, within the 30-day washout period required by law, approach the point where foaming will occur, and the common practice is to have the hostlers who care for the locomotive at each end of the run do such blowing as may be necessary to remove the small accumulation of sludge and at the same time properly reduce the water concentration.

When the total boiler water solids vary between five and twenty grains, then successive evaporations on any trip may cause the accumulated solids to approach the foaming point, and resort must be had either to some blowing on the road, to changing the water at the end of the run, or to a combination of these methods depending upon the conditions of operation and the total solids built up as determined by chemical analysis.

When the dissolved solids in the feedwater exceed twenty grains, still more intensive methods along similar lines will be followed, and if the concentrations become such as to require excessive blowing, as a last resort a little oil on the troubled waters, in the shape of a castor oil anti-foam compound, may be found desirable.

Data collected on various railways and on different sections of the same railway indicate a wide variation in the concentration that may be present when foaming starts. So much depends upon the personal efficiency of the enginemen and the way they have been trained that it is impossible to make a very definite statement, and the actual foaming point must be determined in each case by field tests. On an important railway system operating between Chicago and New York as an average the allowable concentration of solids before foaming starts is considered to be 125 grains per gallon. Carefully conducted tests on another railway in the same general territory show that foaming will develop at between 165 and 180 grains. The diagram presented herewith illustrates a practical method of displaying the combined results as determined by chemical analysis of the water and observation of the locomotive on five round trips over an operating division. No anti-foam compound was used in this case and reliance was placed on holding the water down to a satisfactory concentration by blowing as noted. On the basis of the information developed instructions were given to blow-down two full gage glasses at the end of the run and two at the start of the run, a complete water change at the end of the round trip and a boiler wash at 30-day intervals. In case of trouble on the road the enginemen were instructed how to remedy by further blowing. On a western road with bad water conditions where treatment leaves the total solids in excess of twenty grains per gallon, and engines go 75 miles between water stations, boiler concentration on a 900-mile run will gradually work up to 220 grains notwithstanding a three per cent blow-down. Anti-foam to the extent of a pint per 5,000 gallons of feedwater is therefore prescribed as an aid in maintaining satisfactory operation.



RESULTS OF NORTH BOUND INVESTIGATION

TRIP NUMBER	1000	1002	1004	1006	1008
DATE	DEC.29-30	JAN.2-31	JAN.4-31	JAN.6-31	JAN.8-31
TYPE BLOW DOWN	NONE	INTERMITTENT	3/16" φ CONTINUOUS	1/4" φ CONTINUOUS	7/32" φ CONTINUOUS
WATER BLOWN OUT	NONE	2,698	2,878	5,573	3,399
WATER EVAPORATED	32,319	27,302	23,774	30,699	24,490
TOTAL WATER USED	32,319	30,000	26,652	36,272	27,889
RATIO OF WATER EVAPORATED TO BOILER CAPACITY	6.5	5.5	4.8	6.1	4.9
PERCENT OF WATER BLOWN TO TOTAL USED	—	9 %	10.8 %	15.4 %	12.2 %

RESULTS OF SOUTH BOUND INVESTIGATION

TRIP NUMBER	1001	1003	1005	1007	1009
DATE	DEC.30-30	JAN.3-31	JAN.5-31	JAN.7-31	JAN.9-31
TYPE BLOW DOWN	AS NECESSARY TO CONTROL FOAMING	INTERMITTENT	3/16" φ CONTINUOUS PLUS INTERMITTENT	1/4" φ CONTINUOUS	NONE
WATER BLOWN OUT	2,600	2,442	4,381	4,034	—
WATER EVAPORATED	28,518	23,773	22,096	20,364	21,402
TOTAL WATER USED	31,118	26,215	26,477	24,398	21,402
RATIO OF WATER EVAPORATED TO BOILER CAPACITY	5.7	4.8	4.4	4.1	4.3
PERCENT OF WATER BLOWN TO TOTAL USED	8.3 %	9.3 %	16.5 %	16.5 %	—

FOAMING INVESTIGATION DEC. 29, 1930 TO JAN. 10, 1931. TO ACCOMPANY REPORT OF SUBCOMMITTEE NO 4 ON WASHOUTS WATER CHANGES AND BLOWDOWN.

Extreme Cases

An efficient engineman educated to poor water conditions operating a locomotive with a boiler of the usual design will not carry more than one to two inches of water in the glass. In western bad water territory some enginemen, who early in their career learned to get along with extremely bad water conditions prior to the days of water treatment, prefer to carry the water almost continuously about even with the bottom of the water glass, or "in the nut" in locomotive parlance. In a performance test some months ago an engineman of this school was successfully carrying a boiler concentration of 300 grains per gallon and handling maximum tonnage. Concentrations similar to this have also occurred on fast passenger runs, but the operation in such cases was made possible only by reason of the use of an excessive quantity of anti-foam compound.

Boiler Design

The variation in the performance of different types of power under the same or similar water conditions shows that the design of the boiler also has an effect particularly as regards foaming tendencies. Where seventeen inches of steam space is allowed, conditions are markedly better than where there is only fourteen inches. The tendency to foam is a function of the evaporation rate to which the boiler is subjected, and with boilers worked at the high evaporation rate of approximately 300 pounds per square foot of water surface per hour, as is common with freight power in this country, every inch of increased steam volume is of decided advantage. This indicates the desirability, within safe limits, of carrying low water in the glass and thus increasing the available steam space.

Enginemen as a rule dislike to blow-down and therefore it is important that the blowing-off arrangements be made as convenient as possible. Blow-off openings are usually 1½ inches in diameter and will pass between 100 and 150 gallons of water per minute depending upon the boiler pressure. In some cases use is made of a ¼ inch blow-off intended to operate continuously. This is in successful use on some passenger runs. To decrease the liability of personal injury blow-off pipes discharging to the side are sometimes turned down at an angle of about 30 degrees. Blowing-off where extensively practiced usually is objected to by the Operating Department, and mufflers which function to decrease the velocity of the water and discharge it in such manner as not to damage the roadbed of smear passenger or other equipment are desirable. Designs recently brought out give excellent results. Mufflers are particularly desirable on engines working in congested districts where blowing may be essential for good operation and yet there is no space where the blow-off may be freely discharged.

Boiler Washing

The law requires that a boiler must be washed every thirty days. Obviously if the feedwater is of such quality that very little scale is accumulated, the concentration of soluble salts if excessive in a shorter period can readily be removed by draining the boiler and refilling with fresh water. This can be done at less expense than by a complete wash requiring removal of washout plugs and is the standard practice on most roads.

Water softening which now has a wide application is intended to remove practically all of the insoluble material. Where the carbonates of calcium and magnesium predominate, lime in the softening process removes them causing a decrease in total solids, but the addition of soda-ash for the removal of the sulphate hardness makes no decrease in total solids and usually there is a small increase by reason of the excess chemical weight required to accomplish the reaction in cold water. Thus, unfortunately the

softening process often adds some small amount to the total dissolved solids and thereby increases the foaming tendencies. In the normal softening process we may say that the scale-forming solids remaining in the treated product do not usually exceed ¼ to ½ pound per 1,000 gallons. This is not usually sufficient to make enough sludge to require removal aside from what is accomplished by draining the boiler or blowing down in the interval between regular washouts. As a rule, therefore, the boiler washing period under treated water conditions should be made thirty days. Where water conditions vary from the above, a conscientious, experienced boiler man should be the best judge as to frequency of wash required.

Water Changes

The frequency of water changes will depend entirely on the local conditions and particularly the quality of the water. The incrusting solids having been practically all removed where treated water is used, the total dissolved solids as ordinarily concentrated in the boiler during each trip will govern the water changes required. Either the boiler water concentration may be reduced below the foaming point by blowing on the road, by blowing at the terminal or by changing the water. Obviously from the boilermaker's standpoint the ideal condition is to maintain the boiler in a hot condition as large a share of the time as possible and thus avoid the strains due to temperature changes. If the blowing is done at the terminal by the hostlers, then the engine should be brought in with a sufficiently good fire to allow a thorough blowing down and refilling. The concentration built up in regular operation will govern the proper method to be used. Some feel that blowing on the road creates an excessive fuel loss, but the fact should not be overlooked that it is mostly hot water which is blown out, and this does not contain the latent heat of vaporization. Assuming that approximately one pound of coal is consumed per three gallons of water blown out, a check of the blowing done on a long engine run in the Northwest shows roughly one pound of coal per mile required for this purpose, and this is hardly sufficient to be reflected in fuel performance.

Conclusions

1. A schedule for washouts must be governed by local conditions and particularly the quality of the feedwater. This makes it impractical to outline a program for general application. In districts where all the water is fully treated, thirty days between washouts is usually the practice with water changes between as found desirable.

2. Schedules for blowing down likewise vary with the water quality and should be determined for each district from a study of the boiler water concentrations and the field operation.

3. Water changes are merely exaggerated blow-downs, and necessity for same will depend on the blowing schedule while enroute over the district and the water quality.

4. Here, as elsewhere, the human factor is of first importance. The man at the throttle can make the best of water carry-over with the steam by careless handling. If he has been well-trained, he will carry a reasonable amount of water in the glass, sense the proper time and amount to be blown, and turn the locomotive over to his successor in practically as good condition as when it left the enginehouse.

5. Adequate supervision and chemical check tests are necessary to accomplish regular and satisfactory results and secure maximum economies from the regulation of blowdown, water changes and washout schedules.

Appendix E

(7) APPLICATION AND COMPARATIVE ECONOMY AND EFFECTIVENESS OF VARIOUS COAGULANTS USED IN CONNECTION WITH SOFTENING AND CLARIFYING WATER FOR LOCOMOTIVE BOILERS

W. O. Towson, Chairman, Sub-Committee; J. H. Davidson, J. H. Gibboney, C. H. Koyl, J. J. Laudig, S. B. Mitchell, W. B. Nissly, O. T. Rees, R. M. Stimmel, C. P. VanGundy, J. B. Wesley.

Coagulants have been used by railroads for many years, in connection with softening and clarifying water for locomotive boiler use. With the demand for most economical maintenance and operation of motive power, together with the influence of water quality on the movement of trains and the condition of boilers, the importance of a water supply which is not only properly treated but clarified as well, is being more and more appreciated. Suspended matter permitted to enter the steam boiler increases the mineral content of the boiler water so that foaming tendencies, especially if alkali salts are present, may be increased. The suspended matter may deposit entrained with the scale increasing its bulk or may alone cause serious damage to sheets and tubes. The removal of suspended matter before the water enters the boiler and the further reduction of the hardness of treated water, which frequently results from the use of coagulants, produces cleaner boiler water with corresponding decreased need of boiler washing, water changes, and blow-downs.

Water clarification may be accomplished by long-time settling or sedimentation, filtration, or the use of certain chemicals known as coagulants. A combination of these methods is frequently used. Although all these systems are used by railroads the application of a chemical coagulant is most general. This is the only means for water clarification with which the report is concerned.

A coagulant is a substance which will form a gelatinous floculent precipitate. This "floc" or precipitate carries down color, turbidity, and bacteria. Chemical coagulants are used by railroads for the removal of mud and suspended matter from both raw and treated waters, for speeding up and assisting water softening reactions and frequently where filters are used to prepare the water for the filters. On page 165, Vol. 30, A.R.E.A. 1929, Proceedings, is a report of the Water Service and Sanitation Committee on the use of gravity and pressure filters. It is stated in this report that coagulants should be used to expediate settling, when filtering raw water, if suspended matter is not reduced to 40 p.p.m. after 26 hours standing. Otherwise plain sedimentation is usually adequate.

There are many factors which affect the efficiency of coagulants. These include water temperature, character of the suspended matter, alkalinity, hydrogen ion concentration, soluble salts present, as well as proper application of the coagulant and proper agitation or mixing.

Due to these many influencing factors each water supply, or even one supply seasonally, requires special attention and study to determine the most effective and economical amount and kind of coagulant to be used. When feasible the control may be obtained by use of laboratory or plant "jar" tests. Details for performing these tests may be readily obtained from articles on the subject of coagulation. There are a few general rules which must be observed if typical results are to be expected. Particular attention must be given the agitation or stirring of the mixture being tested. With too

violent agitation "floc" formation is prevented or broken up. As this is likely to occur with ordinary shaking, mechanical stirring is recommended. Constant and regular stirring, instead of shaking, with a speed of thirty to forty revolutions per minute for a thirty minute period, is recommended. The greatest difficulty encountered in performing the tests is early recognition of "floc" formation. The first or working "floc" is far too small to be seen with the eye or through the microscope. This first precipitate may be recognized by means of the Tyndall effect and the particles in the test solution seen in a shaft of light. It is also reported that "floc" formation may be made visible by adding to the test solution some electrolyte, such as sodium sulfate. The use of jar tests is suggested as a guide for selecting a coagulant and for regulating the amounts to be used.

Suspended matter found in water may be present as a suspension, a colloid, or a mixture of the two. The ordinary suspension consists of material mixed or stirred in the water which will filter out or settle within a reasonable time. Coagulants may be used to increase rapidity of settling. The colloidal form of color or turbidity will not settle or filter out readily, if at all. It has been stated that this colloidal material carries positive or negative electric charges which repel one another, counteracting settling by force of gravity. Upon the addition of the proper coagulant, or electrolyte, those charges are neutralized and the particles coagulate and settle readily.

Hydrogen ion concentration, or the pH value of the water being clarified, is one of the most important factors to be given consideration in selecting a coagulant. The pH value at which optimum coagulation occurs is not the same for all coagulants. The influence of the dissolved salts in a water on "floc" formation is receiving increased attention and investigation. They are in many cases considered as important as the pH value in determining coagulation results.

Plant design, though not so much a factor in selecting the coagulant to be used, is important in obtaining the best results with any coagulant. Too violent agitation or mixing, or too rapid velocity of water in the plant may prevent satisfactory coagulation and settling.

There are numerous coagulants in use on railroads at the present time. A questionnaire was sent to several railroads to determine the coagulant used, advantages and disadvantages of each, methods of application, and economies effected. A summary of the answers obtained is given below.

Kinds of Coagulants Used and Results Obtained

The most widely used coagulants are lime, sodium aluminate, sulphate of alumina (filter alum) and iron sulphate (copperas). Experiments have been conducted using ferric chloride, ferric alumina, and magnesium sulphate with sodium aluminate.

LIME.—This chemical which is used extensively in water softening also acts as a coagulant in water containing a relatively large amount of magnesium. The magnesium hydroxide formed has properties similar to iron and aluminum coagulants, but to a lesser extent. Lime is seldom used by railroads for its coagulating property except in connection with water softening and even then a special coagulant is frequently used.

SODIUM ALUMINATE.—This is available in the dry form and in solution. It is used both for mud removal and with lime and soda-ash to speed up chemical reactions and clarification. A treated water may often be obtained when aluminate is used, with a lower residual hardness than could be obtained otherwise, except by increased overtreatment. Some reports indicate decreased after precipitation of the treated water so that deposits in pipe lines, etc., are reduced. It is also claimed that the sludge formed in boilers, when aluminate has been used, is composed of larger particles and that foam-

ing tendencies are reduced. Sodium aluminate has an advantage in that products requiring additional softening are not formed in the reactions occurring, so that the alkali salt content of the water is not increased by its use.

There are several methods of application. Formerly a separate feeder was used for the introduction of both the dry and liquid forms and the aluminate was added either before or after the lime and soda-ash. Many roads report successful results with the addition of aluminate to the mixing vat with the lime and soda-ash.

Sulphate of Alumina or "Filter Alum".—This is available in 100 or 200-lb. sacks, 400-lb. barrels or in bulk. It is used extensively as a coagulant for raw and treated waters. Alum will produce coagulation in raw waters, if there is sufficient alkalinity present, without the addition of any other chemical. Every grain of alum used requires approximately ½ to ¾ grains of alkalinity in the water to produce coagulation. There must be approximately ½ grain alkalinity in the water in excess of that required for coagulation to obtain best results. Some reports indicate that, even if adequate alkalinity is present, improved results are obtained by the addition of a small amount of lime. If sufficient alkalinity is not present to take care of the alum, lime or soda-ash must be added to artificially produce this required alkalinity. Alum reacts with the alkalinity in the water as follows:

$$Al_2(SO_4)_3 + 3\,Ca(HCO_3)_2 = 2Al(OH)_3 + 3CaSO_4 + 6\,CO_2$$

The formation of these products is one disadvantage of alum as a coagulant. If the water is softened approximately ½ grain of lime and ½ grain of soda-ash is required to neutralize the calcium sulphate and free CO_2 formed. The dissolved solid content of the treated water will be increased accordingly. However, the amount of alum required is usually small and this was not reported as a serious objection. If the water being clarified is a raw water sufficient lime should be added to the water after coagulation to prevent corrosion of pipe lines, etc., due to the free CO_2. The range maximum insolubility of alum floc is from approximately pH 5.0 to pH 8.2.

Alum is generally applied to the raw water box or to the raw water in the supply line to the treating plant. For continuous process treating plants it is usual to dissolve the coagulant in a separate vat and feed with automatic proportioning equipment. However, a few roads report the addition of alum to the lime, soda-ash vat with success. In this case the alum is sometimes dissolved before adding to the vat. The dosage varies from one to five grains per gallon and is reported to be only approximately proportional to the turbidity.

Sulphate of Iron or Copperas ($FeSO_4$—$7H_2O$).—This is available on the market as "sugar sulphate of iron" in 25 pound paper cartons, 100 or 200-lb. bags, in barrels, or in bulk. It is used extensively by a few railroads for removal of turbidity. It is readily soluble in water and is cheap in price. Its reaction as a coagulate is seldom complete in natural water unless lime has been added to neutralize free carbon dioxide and best results are obtained if the pH is above 9. The hydroxide formed is not soluble in the presence of caustic lime so that it is especially satisfactory with lime, soda-ash treated waters. Some of the disadvantages are decreased alkalinity and increased sulphate hardness as with alum, acid properties of the sulphate of iron solution, and tendency to break up the iron floc with improper agitation. Acid resisting metal and wood or concrete material is recommended for handling the solution. Air agitation should not be used for mixing as air tends to oxidize the ferrous iron.

Ferric chloride, ferric alumina, experimented with as coagulants, were pronounced as unsuccessful, especially due to difficulties in handling on account of their corrosive

properties. Magnesium sulphate, with sodium aluminate, has been tried as a coagulant in low hardness natural waters. Results were not reported as fully satisfactory.

Savings Effected by the Use of Coagulants.—Approximately 75 per cent of the railroads answering the questionnaire reported the use of coagulants. The benefits listed included reduction of pipe line stoppage and wear on valves and pumps, as well as eliminating deposits of mud in the boilers. A cleaner boiler water decreases the foaming tendency and permits decrease in blow-downs, water changes, and washouts.

It appears that very little data has been compiled to show the actual savings effected in terms of dollars and cents. Though information as to savings is not available the answers received indicated that the additional cost resulting from the use of coagulants is justified.

Appendix F

(10) ADVISABILITY OF STANDARDIZING VALVES AND PACKING FOR WATER SERVICE PUMPS

J. P. Hanley, Chairman, Sub-Committee; C. H. Fox, J. R. Hickox, R. L. Holmes, W. A. McGee, J. A. Russell, R. A. Tanner, J. B. Wesley.

GENERAL

Your Sub-Committee sent a questionnaire to railways represented on the Water Service Committee to ascertain the extent of standardization and methods followed in ordering valves and pump packing. Twenty-two replies were received which indicated that one railway ordered rubber valves and one railway ordered pump packing on specifications. Two railways reported the use of standard charts giving instructions for ordering proprietary brands of packing for various types of pumps. With these exceptions the railways reported that they purchase valves and packing in the open market or from manufacturers' catalogs.

The report deals with rubber valves. Valves of other materials are used in a limited way and their use and purchase should be considered as individual cases and handled in accordance with local conditions.

RUBBER VALVES

In ordering valves the thickness, diameter and size of hole are given, the class of service for which required such as hot or cold water. In some cases the word "hard," "medium", or "soft" is added to indicate the service conditions. These simple specifications appear adequate for the purchase of satisfactory valves and permit the manufacturer to base bids on stock material.

The increasing use of centrifugal pumps which require no valves instead of piston pumps which required many valves is decreasing the need for this class of material. It is therefore questionable if necessity exists for railway specifications for pump valves especially if the specifications would add the expense of another line to existing manufacturers' stocks.

PACKING

With two exceptions the railways reporting indicated that they use the packing manufacturers' lists in ordering packing, giving the size of the packing required and stating the service intended, such as steam or water. A considerable variety of pack-

ing is now on the market, the cheapest grades being made of jute, cotton and flax in the form of loosely plaited rope strands saturated with graphite grease or other lubricant. Packing of this kind has been extensively used since the early days of pump and machinery operation and still gives satisfactory and inexpensive service at many railway water stations. It may be removed from the packing box after it becomes hardened by compression, treated with more lubricant and used for repacking. On account of loose strand construction, it is adaptable for all sizes of packing boxes and may be used for steam or water.

The packing manufacturers have augmented this simple packing with a great variety of other types made of jute, hemp, flax, rawhide, asbestos, rubber and metallic compositions. The packing is also supplied in a variety of shapes and sizes, round, flat, square and bulk. Packings are also made for many different uses such as acids, air, steam, petroleum and its products and all kinds of chemical solutions. To paraphrase the words of the automobile industry "a packing now exists for every purse and purpose."

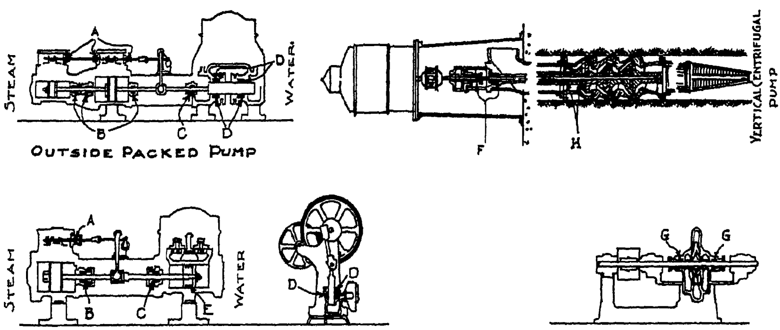
The American Standards Association and Mechanical Division of the American Railway Association have no standards for rubber valves or packing but we found that the Bureau of Standards, Washington, D. C., has extensive specifications covering many varieties of packing and valves, as well as general specifications for rubber goods on which the individual specifications are usually based. Copies of these specifications may be obtained from the Superintendent of Documents, Federal Printing Office, Washington, D. C., for 5 cents a copy. A list of the specifications covering packing and valves follows:

ZZ-R-601—Rubber Goods, General Specifications
HH-P-46—Packing; Asbestos, Sheet, Compressed
HH-P-161—Packing; Rubber Wire Insertion

Bureau of Standards No. 363—Master Specifications for Flax Packing
Bureau of Standards No. 111b—Packings and Gaskets, Rubber (molded sheet and strip)
Bureau of Standards No. 334—Master Specifications for Packing, Asbestos, Wick and Rope
Bureau of Standards No. 236—Master Specifications for Cloth Insertion Rubber Packing
Bureau of Standards No. 335—Master Specifications for Packing, Hard Fiber Sheet
Bureau of Standards No. 240—Master Specifications for Diaphragm Packing
Bureau of Standards No. 224—Master Specifications for Rubber Pump Valves

The Pennsylvania System has specifications for the purchase of packing and the Delaware, Lackawanna & Western Railroad Company has specifications for the purchase of rubber pump valves.

Your Committee has studied the Federal Specifications, and the specifications of the railways mentioned and believes that the specifications in use by the Pennsylvania System covering packing and the Federal Specifications covering rubber pump valves should be especially considered by railways interested in drafting specifications of these items as these specifications present the briefest forms in general use. A chart is submitted with this report showing a method of charting proprietary brands of packing for specific types of pumps. This chart may be used by railways who have no specifications, as it gives systematic instructions for using selected brands of packing available in the market.



INSIDE PACKED PUMP — VERTICAL, OUTSIDE PACKED PUMP — HORIZONTAL CENTRIFUGAL PUMP

SPECIFY SIZE, REFERENCE NUMBER, AND QUANTITY OF PACKING REQUIRED ALSO CLASS OF SERVICE FOR WHICH USED IN ACCORDANCE WITH FOLLOWING KEY

A

STEAM – Valve stem stuffing box.
Use.-

B

STEAM – Piston rod stuffing box
Use-

C

WATER – Piston rod stuffing box
Use:

D

WATER – Outside packed plunger stuffing box
Use:

CHEMICALS – Pumps use:-

E

WATER – Inside packed piston
Use

F

Stuffing gland for upper bearing
Use

G

Main shaft stuffing box
Use:

H

PACKING for lower bearing on oil lubricated deep well turbine pumps
Use

NOTE 1

Where gaskets are required on pumps
Use sheet packing

NOTE 2

Where gaskets are required for water service boilers use:-
MANHOLE
HANDHOLE
TUBE PLATE
Specify size, whether round, square, or oval

AMERICAN RAILWAY ENGINEERING ASS'N
PACKING CHART
for
WATER SERVICE PUMPS

Conclusions

(1) Specifications for packing cover many individual types of unsimilar materials and construction as indicated by the Federal list of specifications. The packing specification recommended for consideration with the report covers a limited number of packings most generally used by railways.

(2) Specifications for rubber pump valves cover a limited field and may be handled satisfactorily by specifications or by ordering from manufacturers' catalogs. Specifications are not usually required.

(3) The use of a chart for ordering proprietary brands of packing for certain types of pumps is satisfactory. It is particularly recommended for use where specifications do not exist.

American Railway Engineering Association

A RESOLUTION

RESOLVED, That the members of the Committee on Water Service and Sanitation of the American Railway Engineering Association, express their deep sorrow at the death of their honored fellow-member

Dr. C. Herschel Koyl

on December 18, 1931. The members keenly realize the loss of Dr. Koyl to the Committee and to the Association. Dr. Koyl was appointed to this Committee in 1920, serving thereon with distinction until his death.

Dr. Koyl contributed freely of his time and talents in the preparation of reports of this Committee. His associates will greatly miss the inspiration of his high integrity, fine character and kindly personality, and they offer their profound sympathy to his family in their bereavement. In his death, the Committee has lost an esteemed member and valued friend.

RESOLVED, That an engrossed copy of this resolution be presented to the family of the deceased and recorded in the Minutes of this Committee.

REPORT OF COMMITTEE I—ROADWAY

C. W. Baldridge, *Chairman;*
J. B. Arter,
H. B. Barry,
A. L. Bartlett,
E. J. Bayer,
A. E. Botts,
W. G. Brown,
T. A. Burgess,
Paul Chipman,
J. D. Elder,
L. C. Frohman,
J. A. Given,
J. N. Grim,
Daniel Hillman,
F. W. Hillman,
Noah Johnson,
R. M. Jolley,
G. E. Ladd,
Harold W. Legro,
E. R. Lewis,
G. S. Fanning, *Vice-Chairman;*
H. T. Livingston,
R. J. Middleton,
W. F. Monahan,
W. A. Murray,
J. A. Noble,
E. C. Oyler,
E. H. Piper,
W. C. Pruett,
W. M. Ray,
C. S. Robinson,
L. S. Rose,
P. T. Simons,
E. M. Smith,
W. C. Swartout,
H. M. Swope,
Jamison Vawter,
O. H. Wainscott,
Thomas Walker,
H. N. White,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report covering the following subjects:

1. Revision of Manual (Appendix A).

It is recommended that the revisions of the Manual and the withdrawals from the Manual under the heading, Specifications for Concrete Fence Posts, as offered in Appendix A be accepted and that the Manual be revised in accordance therewith.

2. Methods of roadbed drainage (Appendix B).

This report is a continuation of the report on the same subject as made and adopted last year and it is the Committee's recommendation that the matter in Appendix B beginning with the heading II "Sub-Surface Drainage" and ending with Article 7, Paragraph P "Inspection" be adopted for inclusion in the Manual. It is also recommended that the matter now in the Manual, page 41, Article 5, "Pipe Drains" be withdrawn.

3. Influences affecting the life of fence wire and methods for prolonging the service life of fence wire (Appendix C).

It is recommended that the report be accepted as information.

4. Permanent roadbed construction (Appendix D).

It is recommended that the report be accepted as information.

5. Specifications for overhaul in grading contracts and a recommended method for calculating overhaul (Appendix E).

It is recommended that the report from the heading "Specifications" to "Note (B)" be adopted for inclusion in the Manual.

8. Use of highway crossing planks and substitutes therefor, collaborating with Committee IX—Grade Crossings (Appendix F).

It is recommended that the report be accepted as information.

Bulletin 342, December, 1931.

10. Means of protecting roadbed and bridges from washouts and floods (Appendix G).

It is recommended that the report be adopted for publication in the Manual.

12. Cause and prevention of heaving of track, due to frost action, and maintenance methods while the effects of heaving are present, collaborating with Committee V—Track (Appendix H).

It is recommended that the report be adopted for inclusion in the Manual.

13. Specifications for pipe line crossings under railroad tracks, collaborating with Committees XIII—Water Service and Sanitation and XX—Uniform General Contract Forms (Appendix I).

It is recommended that it be adopted for inclusion in the Manual.

The Committee reports progress on the following subjects:

6. Drainage areas, water runoffs, and proper size of waterway openings.

7. Methods of correcting soft spots in railway roadbed, where it is impracticable to stabilize by drainage.

11. Specifications for galvanizing metal pipe culverts.

Respectfully submitted,

THE COMMITTEE ON ROADWAY,

C. W. BALDRIDGE, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

A. E. Botts, Chairman, Sub-Committee; C. W. Baldridge, J. D. Elder, Harold W. Legro, R. J. Middleton, W. A. Murray, J. A. Noble.

(a) The following specifications covering the manufacture of concrete fence posts and drawn up in collaboration with Railway Bureau of the Portland Cement Association, are submitted for substitution of the specifications appearing on pages 68, 69, 70 and 71 —1929 Manual.

SPECIFICATIONS FOR CONCRETE FENCE POSTS

Present Form

(I) MATERIALS

Intent

1. The intent of these specifications and the plans of which they form a part is to produce concrete fence posts having a uniform and sufficient strength and durability at a minimum of cost. On account of the thinness of the section, this can only be accomplished by intelligent and constant attention to securing proper proportions of all the ingredients.

Cement

2. Cement shall conform to the present Standard Specifications and Tests for Portland Cement of the A. R. E. A. and subsequent revisions thereof.

Proposed Form

(I) MATERIALS

Cement, aggregate, water and metal reinforcement shall conform in quality to the specifications for concrete of the A.R.E.A. as given under the subject "Masonry" except that the maximum size of aggregate shall be not more than ¾ the clear imbedment distance. Reinforcement shall be in the form of round or square bars of hard grade new billet or rerolled rail steel or cold drawn steel wires. Crimped, stranded or flat reinforcing shall not be used. When choices can be made between sizes of reinforcement, it is better to use the larger number of smaller bars.

Present Form | *Proposed Form*

Fine Aggregate

3. Fine aggregate shall consist of sand stone screenings, or a combination thereof, having clean, hard, strong, durable, uncoated grains and free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances. It shall range in size from fine to coarse, preferably within the following limits:

Passing through a No. 4 sieve....... ....not less than 90%
Passing through a No. 50 sieve...... ....not more than 30%
Weight removed by decantation..... ....not more than 3%

Sand shall be tested for organic impurities as follows: Fill a 12 oz. graduated prescription bottle to the 4½ oz. mark with the fine aggregate to be tested. Add a 3 per cent solution of sodium hydroxide until the volume of the sand and solution, after shaking, amounts to 7 oz. Shake thoroughly and let stand for 24 hours. If the solution resulting from this treatment is darker than straw color the fine aggregate shall not be used unless the concrete made with the materials and in the proportions to be used in the manufacture of concrete posts is shown by tests to be of the required strength.

Coarse Aggregate

4. Coarse aggregate shall consist of crushed stone, gravel, or combinations thereof, having clean, hard, strong, durable, uncoated particles free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter. It shall range in size from fine to coarse within the following limits:

For line posts:
Passing a ½ in. screen........... ....not less than 95%
Passing a No. 4 screen........... ....not more than 15%
Passing a No. 8 screen........... ....not more than 5%

For corner and end posts:
Passing a ¾ in. screen........... ....not less than 95%
Passing a No. 4 screen........... ....not more than 15%
Passing a No. 8 screen........... ....not more than 5%

Present Form

Bank Gravel

5. Natural combinations of fine and coarse aggregate, in the form of bank gravel, may be used, providing its particles meet all the requirements in Sections 3 and 4 above, including the colorimetric test, and provided such particles are properly graded from fine to coarse within the following limits:

Passing a ½ in. screen............ ....not less than 95%
Passing a No. 4 screen............ ....from 40 per cent to 70%
Passing a No. 50 screen........... ....not more than 15%
Weight removed by decantation.... ....not more than 1½%

Water

6. Water for concrete shall be clean and free from oil, or injurious amounts of acid, alkali, organic or other deleterious substance.

Metal Reinforcement

7. Steel reinforcement shall be steel of hard grade and shall conform to the present Standard Specifications for Steel Reinforcement of the A.R.E.A. or, if wire is used, to the present Tentative Specifications for Cold-Drawn Steel Wire of the A.S.T.M., or to such modifications of either of such specifications as may hereafter be adopted by the A.R.E.A. Reinforcement shall be in the form of round or square bars, preferably deformed, or steel wires. Crimped, stranded or flat reinforcing shall not be used. Reinforcing, before being placed in the molds, shall be thoroughly cleaned of mill and rust scale, and of coatings that will destroy or reduce the bond.

(II) Proportioning and Mixing Concrete

Proportioning

8. The unit of measure shall be the cubic foot. One bag of Portland cement shall be considered as one cubic foot. Each of the constituent materials shall be measured separately by volume, using a method which will secure the necessary proportions to produce concrete of the specified strength. The water shall be measured by an automatic device that will secure the same quantity in successive batches.

Proposed Form

(II) Proportioning and Mixing

Proportioning and mixing concrete shall be in accordance with the specifications of the A.R.E.A. for concrete as given under the subject "Masonry" with the exception that the compressive strength of concrete shall vary with the amount of clear imbedment of reinforcement, as follows:

Clear Imbedment Inches	*Class of Concrete Compression Strength Lb. Per Sq. In. at 28 days*	*Gallons of Water per Sack of Cement*
¾	3500	5.00
½	4000	4.50
⅜	4500	4.00

Present Form | *Proposed Form*

Strength

9. The proportions of cement, water and aggregate shall be such as to produce a concrete having a compressive strength at 28 days of 2500 lb. per square inch. The proportions of fine and coarse aggregate to produce such a concrete shall be determined by making a screen analysis of the available aggregates and using such a mixture of cement, aggregate and water as will give a dense, workable concrete of the desired strength.

Consistency

10. The quantity of water used in mixing shall be the least amount that will produce a plastic or workable mixture which can be properly compacted in the forms and around the reinforcement. Under no circumstances shall the consistency of the concrete be such as to permit a separation of the coarse aggregate from the mortar in handling. The consistency shall be measured by the slump test as follows:

The newly mixed concrete shall be placed in a truncated cone-shaped metal mold, 12 inches high, 8 inches in diameter at the base, and 4 inches in diameter at the top, and provided with handles at the sides. The concrete shall be lightly tamped with a rod as it is placed in the mold which, when filled, shall be immediately removed and the slump or settlement of the concrete noted.

The maximum slump shall not exceed 5 inches. The consistency shall be checked at the beginning of each daily run and also whenever there is a change in the size or moisture content of any aggregate.

Mixing

11. Mixing shall be done in a batch mixer of approved type, equipped with a suitable charging hopper, water storage, and water measuring device. The entire contents of the drum shall be discharged before recharging. Each batch shall be mixed for not less than 2 minutes after all the materials are in the mixer, during which time the mixer shall rotate at a peripheral speed of about 200 feet per minute. The volume of the mixed batch shall not exceed the manufacturer's rated capacity. The retempering of concrete which has partially hardened shall not be permitted. In cold weather aggregate shall be heated, if necessary, to remove frost and frozen lumps.

Present Form

(III) Depositing Concrete

General

12. Before depositing concrete the molds shall be thoroughly cleaned and coated with non-staining mineral oil or other approved material. The mixer should be so located that the concrete can be discharged directly into the molds or conveyed to the molds in such a manner as to cause no separation of the ingredients. Each mold shall be completely filled in one continuous operation.

Molds

13. Molds shall be substantial, rigid and true to plan. Metal molds are more satisfactory than wooden molds.

Placing Reinforcing

14. The reinforcing shall be securely and continuously held in its proper position in the post during the placing of the concrete and until the post is removed from the mold. Metal spacers that would cause distinct lines of cleavage in the post shall not be used. The reinforcing shall be supported as often as is necessary to prevent its sagging to any appreciable extent due to its own weight or to the weight of the wet concrete.

Compacting

15. Concrete shall be thoroughly compacted into the molds and around the reinforcing. This is best accomplished by giving the molds a jogging or vibratory motion during and after depositing.

Finish

16. All posts shall have a clean, smooth finish. If any pockets or holes are discovered upon removal from the molds, they shall be immediately filled with a mixture of one part cement to two parts fine aggregate. Pockets or holes more than ½ inch in depth or more than ½ inch in diameter, or any exposure of the reinforcing shall cause the rejection of the post.

(IV) Curing and Handling Posts

Curing

17. The posts shall remain in the molds until the concrete has thoroughly hardened and in no event for less than 24 hours after placing. During this time and until they are cured the posts shall be care-

Proposed Form

(III) Manufacture

Molds

Molds shall be substantial, true to plan and preferably of metal. They shall be thoroughly cleaned before concrete is placed.

Placing Reinforcing

The reinforcing shall be securely held in position during the placing and setting of concrete. Spacers that would cause distinct lines of cleavage shall not be used.

Compacting

Concrete shall be thoroughly compacted into the molds and around the reinforcing. This is best accomplished by high frequency vibration of the molds.

Finish

Imperfections such as exposure of reinforcing, sand streaking due to loss or lack of cement paste, honeycomb clusters or pockets of coarse aggregate without proper mixture of the finer components of concrete, cracks or other evidence of improper mixing or faulty construction shall cause the rejection of the post. Patching will not be permitted.

Curing

Curing shall start immediately after placement of concrete and shall extend for the following periods of time depending upon the temperature uniformly maintained during the curing period:

Present Form

fully handled and protected from shock. When the posts are removed they shall be stacked in a nearly vertical position and protected from direct sunlight. They shall be kept thoroughly wet for eight or ten days after being made. They shall be cured for not less than 90 days, when cured naturally, before being shipped or set. Posts shall not be cured out of doors during freezing weather.

Proposed Form

Temperature Degrees F.	*Curing Period in days*
50	14
70	10
90	7
120	2

Temperatures exceeding 140 deg. Fahr. must not be used. No evaporation or other loss of moisture from the concrete shall be permitted during the curing period, or while cooling off after heat curing.

(V) Miscellaneous

Inspection

18. All materials and all processes of manufacture shall be subject to inspection and approval at all times. Free access shall be provided for all authorized inspectors to all parts of the plant in which the posts or the materials are made, stored or prepared.

Inspection

All materials and all processes of manufacture shall be subject to inspection and approval at all times. Free access shall be provided for all authorized inspectors to all parts of the plant in which the posts or the materials are made, stored or prepared.

Tests

19. All testing of materials used in the manufacture of posts, all preparing, storing and testing of concrete specimens, as provided in Section 8 hereof, and all screen analyses of aggregates, shall be made in accordance with the methods adopted or approved by the A.R.E.A. and in effect at the time such tests, analyses, etc., are carried out. In case the A.R.E.A. shall not have approved or adopted any methods for such tests, analyses, etc., the same shall be made in accordance with the methods then adopted or approved by the A.S.T.M.

Tests

Posts should be carefully made so as to secure a uniform strength in substantially all posts, and this strength should usually be such that the post will withstand a force of not less than 180 lb. at right angles to the axis of the post, the post acting as a cantilever beam supported at the ground line and the force being applied 60 in. above the ground line.

During the curing or cooling off period posts, submerged in water for two hours and wiped off, shall not show an increase in weight. The same test applied to finished post after drying at 70 deg. Fahr. for sixty hours shall show an increase in weight of not more than one per cent.

Patents

20. The manufacturer or contractor shall pay all royalties for the use of patented designs or devices or forms of construction and protect the Railway Company from all claims of infringements or liability for the use of such patents.

Patents

The manufacturer shall pay all royalties for the use of patented designs or devices or forms of construction and protect the Railway Company from all claims of infringement or liability for the use of such patents.

Appendix B

(2) ROADBED DRAINAGE

G. S. Fanning, Chairman, Sub-Committee; A. L. Bartlett, F. W. Hillman, G. E. Ladd, E. R. Lewis, W. F. Monahan, E. H. Piper, E. M. Smith.

Consideration of this subject has been continued in accordance with the outline adopted last year (Proceedings, Vol. 32, p. 170) and the following report is offered on the subject "Sub-Surface Drainage Pipe Drains":

(II) SUB-SURFACE DRAINAGE

Definition

1. Sub-surface drainage may be defined as the control and removal of excess moisture contained in the soil.

Soil Moisture

2. Excess soil moisture in the roadbed is detrimental in four respects: (a) it greatly reduces the bearing power of soils of all kinds, some more than others, resulting in "soft spots"; (b) in case of freezing it causes "heaving"; (c) in case of increase or decrease of amount of excess moisture, unequal swelling or shrinkage results in unequal displacement of the track; and (d) it leads often to subsidences and slides.

The moisture in the soil which is of importance is of two kinds: gravitational and capillary.

Gravitational water is free to move under the influence of gravity. It can be removed by ditches, drain pipes or other drainage means.

Capillary moisture is tenaciously retained in soils through which free water has passed or which are in contact with wetter soils by the attraction between the soil particles and water and the surface tension of the water. It is only removable from soils by evaporation, and by that only in part, and while connection with any source of water is removed. It cannot be removed directly by drainage, but can be controlled somewhat by lowering the water table. The amount of capillary moisture which can exist in a soil depends upon the shape, size and mineralogical composition of the soil particles; the greater the proportion of surface area of the particles to the mass and the greater the percentage of clay, the greater the amount of capillary water.

Soils

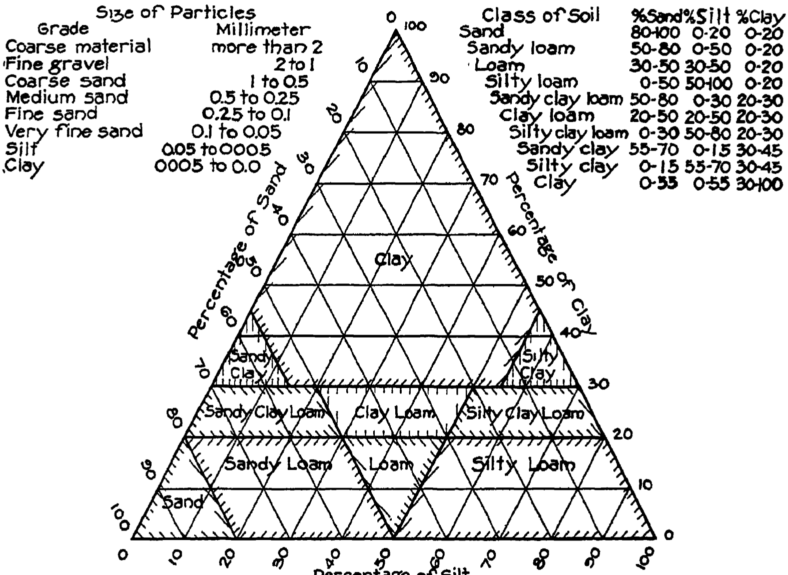
3. Drainage problems are definitely related to the mineralogical composition of the material involved, the physical condition of the mineral material, and the local geological and climatic conditions which determine the source, or sources, of water.

The United States Bureau of Soils has classified soils as to texture as indicated graphically in the tri-axial soil classification chart (Fig. 1).

The adverse character of a roadbed soil depends on (1) its volume change with variations in moisture content or under frost action, (2) its plasticity, that is, its tendency to flow under load which affects its bearing power, and (3) its tendency to flow as a result of rounded sands and silts. The track may be displaced as a result of any one of these conditions. The Kaolinite group and other micaceous-like minerals, important constituents of clays, affect the moisture content of a mass and its plastic properties in proportion to the extent to which they have been broken up along cleavage

planes into thin plates (surface relative to mass increased). So far as stability of a mass is concerned, the term "sand", unless qualified, is misleading. Wet or dry, highly rounded sand and siliceous silts, behave very differently from angular sand and silt.

The adverse character of a soil, as affected by the presence of water and manifested by vertical swelling, increases with the clay content.



TRI-AXIAL SOIL CLASSIFICATION CHART

FIG. 1.

Field Test for Soils

4. The clay content of a soil is indicated and the soil identified as good, doubtful or poor for use as a railroad roadbed by a simple and practical field test, known as the "field moisture equivalent test".*

The "field moisture equivalent" is the amount of water, expressed as a percentage of the dry weight of the soil, which it will absorb due to surface tension and adhesion (capillary water). It has been found that generally within the critical limits the "field moisture equivalent" varies directly with the linear expansion of the material due to the absorption of water. The "field moisture equivalent" can be determined by the following method.

Use a small tinned iron pan, say 2 inches by 6 inches by 1 inch deep with many perforations in the bottom. Cover the bottom with thin blotting paper. Weigh the vessel thus prepared. Fill it with the thoroughly dried and powdered material to be tested, not quite to the top after gentle shaking to allow for possible swelling. Weigh again. Set the vessel on a support in a wide pan of water so that surface of water

* "Foundations and Drainage of Highways" by A. C. Rose, Highway Engineer, Bureau of Public Roads, U.S. Dept. of Agriculture. Transactions A.S.C.E. Vol. 93 (1930), p. 62.

just covers the blotting paper. Within an hour or two absorption will be approximately complete. Left over night it will be absolutely complete. Again weigh.

The water content of the soil divided by the dry weight of the soil and the result multiplied by 100 gives the "field moisture equivalent". This percentage can be determined accurately for soils if it is 20 or greater. Soils with lower values than 20 are so coarse grained as to drain readily and therefore are practically always good sub-grade soils. The "field moisture equivalents" of a large number of soils within the critical limits have been observed to be numerically similar to the clay content of the soil in percentage as determined by mechanical analyses. The "field moisture equivalent" may therefore be assumed to indicate the percentage of clay content, eliminating the necessity for the more difficult mechanical analysis.

Reconnaissance soil surveys may be made by the use of a U. S. Bureau of Soils map in connection with the tri-axial soil classification chart (Fig. 1)· without the use of tests.

The use of the "field moisture equivalent" and the clay content to indicate good, doubtful and bad sub-grade soils is not claimed to be positive under all conditions. It is significant in a great majority of cases.

Generally speaking, soils with less than 20 per cent clay, i.e., sands, sandy loams, loams and silty loams are considered to be good sub-grade soils; soils with 20 to 30 per cent clay, i.e., sandy clay loams, clay loams and silty clay loams, also sandy clays and silty clays, doubtful sub-grade soils; and clays, bad sub-grade soils.

Necessity for Drainage

5. The drainage condition of a sub-grade soil, as well as the bearing power, is poor when the actual moisture content of the soil exceeds its "field moisture equivalent".

Water Cut-off

6. Drainage in a broad sense involves both constant elimination of excess gravity water, and the prevention of access of water to the mass under consideration. The latter problem has to deal with lateral seepage or sub-surface flow (in volume); with vertical or lateral capillary action; and with direct access of water from rainfall.

Capillary water, from below, may be cut off by a layer of gravel or broken stone eight to ten inches in thickness. It may be cut off laterally either by ditches or by gravel-back-filled trenches. Laterally free-moving water may be cut off by trenches, gravel-back-filled, and sometimes by open ditches. Cut-offs are often necessary beneath ballast, down into undisturbed natural ground, at right angles to tracks. On down grades this will eliminate the necessity of considerable drainage of "soft spots". Sometimes "moving ground", going away from a position below and near roadbed, removes necessary support, or such ground threatens to overwhelm roadbed from above. In either case it may be necessary to prevent absorption of direct rainfall by thoroughly oiling such a surface.

Drainage of Open Soils

7. If the actual moisture content of an open soil (less than 20 per cent clay) exceeds its "field moisture equivalent", it is an indication that the soil lies below the water table in a stratum bearing free water. Where this is due to surrounding or underlying impervious strata, the high water table in an open soil may be lowered by one of the three following methods:

(a) Provide an outlet through the surrounding material.

(b) Drill through the impervious bottom of the area to permit the water to escape through lower pervious strata—if such strata exist.

(c) Place sub-drain pipe at such depth as to lower the water table below the level of adverse effect. An outlet is essential.

Such water bearing materials may be encountered in cuts or under side-hill fills. The source of the water must be determined. This may be a spring, flowing under hydrostatic head from a higher area; it may be a thin water-bearing seam in rock or in an impervious soil; it may be a thicker water-bearing stratum emerging on a side slope, or it may be that only the upper portion of a thick water-bearing stratum is intercepted.

Drainage of Impervious Soils

8. If the actual moisture content of a less pervious soil (more than 20 per cent clay) exceeds its "field moisture equivalent", there is also free water present which should be removed by sub-drainage. The lowering of the water table in such soils also tends to decrease the amount of capillary moisture near the sub-grade surface. Some of the denser clays are so impervious as to entirely prevent the passage of free water through them; drain pipes are of no value in such soils. It is preferable to keep the water away from such soils in the first place, as they retain extremely high percentage of capillary water.

Pipe Drains

9. Except in impervious soils, efficient sub-drainage of wet cuts and of saturated soil upon which embankments rest may be attained by the use of pipe drains.

a. Location. In cuts the main pipes should be laid parallel to and nine feet from the center line of the adjacent track. Along embankments the location should be about ten feet from the toe of slope, thus keeping the pipe away from the zone of subsidence under the fill and outside of the deposit of sediment washed down from the slope.

b. Grade. The grade of the pipe should not be less than 0.2 per cent; preferably 0.4 per cent or better where practicable. Mains should where possible be laid on a uniform grade or with grade increasing towards the outlet; where a reduction in grade is unavoidable, an adequate catch-basin should be provided.

c. Depth. The depth may depend wholly on the level of the water source. A minimum depth of three feet below bottom of ditch or six feet below sub-grade in cuts or six feet below natural ground surface along fills is recommended. Care should be taken to locate the pipe at such depths that no displacement will be made in the alinement or grade of the pipe by the subsidence of the roadway under traffic or by the action of frost. To this end the trench in which the pipe is to be laid should be dug down into a motionless stratum underlying the saturated material which it is desired to drain. Where this is impracticable some means of curing the situation, other than by drainage, must be adopted.

d. Size. The minimum inside diameter of pipe for main drains should be six inches. In long wet cuts the diameter of the pipe should be increased at intervals between source and outlet as the increasing inflow demands, from six to eight to ten to twelve inches, etc., as necessary.

e. Laterals. In extremely wet cuts, the mains alone may not be sufficient and laterals extending under the track may be required. These should be spaced from 10 to 40 feet apart, depending on the character of the material to be drained. A minimum

grade of 4 per cent, preferably 8 per cent (1 in 12) should be provided to prevent sedimentation; the maximum grade should be 16 per cent (2 in 12) as with greater grades there is danger of the lateral pushing into the main and causing failure.

f. KIND. The pipe used should (1) have ample strength to sustain safely the load and impact to be imposed upon it, (2) provide initially and maintain continually a high capacity for drainage, unimpaired by the separation of its units or by the admission of soil or rock particles, and (3) have sufficient durability to insure a long service life with resulting economy and freedom from interference with train operation due to renewals.

Two materials are available, each of which, if properly laid, fulfill these conditions. These are (1) No. 1 vitrified clay sewer pipe with bell ends, and (2) corrugated galvanized iron pipe with ¼ inch perforations in the valleys of the corrugations (where the pipe diameter is least) and spaced 1½ inches apart for 120 degrees of the circumference.

The determination as to which to use will depend on local conditions and on the relative costs. Vitrified clay pipe will usually cost less than corrugated iron pipe and is preferable where the excavation is of any considerable depth into firm material or where the water carries sulphur or other chemicals in quantities injurious to iron pipe. Corrugated iron pipe is preferable where the cover is shallow or the material unconsolidated and where vitrified pipe might be subject to breakage or its alinement disturbed by accident or heaving. Corrugated iron pipe is ordinarily not used in sizes smaller than 8 inches in diameter.

g. TRENCH. The cross-section of the trench should be such as to prevent the permeable backfilling being cut off through the temporary heaving of the roadbed before it becomes compacted through drainage. A bottom width of 18 to 30 inches is recommended, with the side away from the track vertical to the surface and the side towards the track vertical to where a 45° slope from the bottom end of the tie is intersected and thence followed. The trench should be excavated 2 to 4 inches below the grade established for the outside surface of the bottom of the pipe. The soil removed to form the trench should not be used for pipe covering nor even deposited in the vicinity but should be hauled away from the site at the time it is excavated.

h. FOUNDATION. The bottom of the trench should be thinly backfilled with a selected permeable material to provide a firm plane surface at the correct grade as a foundation for the pipe.

i. INSTALLING TILE PIPE. Commencing at the lower end, the pipe should be laid with the bell end up grade, leaving the joints open to permit the water to enter.

j. INSTALLING CORRUGATED IRON PIPE. This pipe may be obtained in any lengths in multiples of two feet up to 20 or 30 feet. Normally the pipe should be laid with the perforations in the bottom and with the inside circumferential laps pointing down stream. Laying the pipe with perforations down permits the greatest inflow of ground water with the least intrusion of sediment. The sections are joined by means of corrugated bands. All special fittings, such as catch-basins, manholes, tees, wyes, elbows, crosses and reducers, should be placed as the pipe is laid.

k. OUTLETS. With either type of pipe deep open ditch outlets should be avoided by extending the pipe to shallow cover but not into the frost zone. The outlet ditch should be excavated well below the outlet on a heavy grade. The pipe outlet should be protected by a screen to prevent animals from entering the pipe.

l. Risers. Risers should be placed at the upper end of each main and at intervals of 300 feet along the main to permit of flushing.

m. Backfilling. The entire trench should be backfilled carefully with a selected permeable material, such as clean crushed stone or washed gravel. Engine cinders should be used only when no other satisfactory material is available, but never with corrugated iron pipe on account of the corroding effect of the sulphuric acid which is present in the cinders.

n. Time. On new construction the drainage system should be completed, if it is possible to get the pipe and backfill material to the work, before any track work is undertaken.

o. Record. A complete record should be kept of all drains, which should include a description of kind, sizes, location and depth, so that they may be easily located when necessary.

p. Inspection. A yearly inspection should be made on all sub-drainage systems to assure proper maintenance.

Recommendation

The Committee recommends the adoption of this report for publication in the Manual, replacing the following existing material:

Page 41 "(5) Pipe drains should be provided for the drainage of wet cuts."

The Committee recommends that the subject "Roadbed Drainage" be continued.

Appendix C

(3) INFLUENCES AFFECTING THE LIFE OF FENCE WIRE AND METHODS FOR PROLONGING THE SERVICE LIFE OF FENCE WIRE

W. C. Pruett, Chairman, Sub-Committee; J. D. Elder, L. C. Frohman, Daniel Hillman, E. H. Piper, Thomas Walker, H. N. White

Previous reports of the Committee on this subject have contained information concerning the experiences of a number of users of fence wire, and the results of several actual field tests. (See pages 607, Vol. 26, 425, Vol. 27, and 172, Vol. 32 of Proceedings).

Since it has been determined that no accelerated test, however carefully worked out, will prove in advance the durability of a material under actual service conditions, the Committee has been making a study of field tests and actual uses. Information has been received that in a recent survey by the American Society of Agricultural Engineers it was found that the average span of usefulness of barbed wire in fence is fifteen years. Reports from several railroads indicate that in right-of-way fence particularly in vicinity of industrial centers and in close proximity to the sea coast the usefulness of such wire is only from six to ten years.

Records are available of a section of barbed wire fence that was constructed in 1916 of galvanized ingot iron wire along the main line of the Florida East Coast Railway through the salt marshes adjacent to the Atlantic Ocean. The immediate proximity to this salt water and the prevailing wind from the ocean would indicate very adverse influences affecting the life of this wire. But after fifteen years of service under these severe conditions, this wire retains practically all of its original section. The barbs are

sound and in good condition and the strands appear to be nearly their original strength. On the Okeechobee Branch of this same railroad at a location some twenty-five to thirty miles distant from the Ocean, but along through a swamp, a section of fence was constructed between June, 1918 and October, 1919. The material used was standard galvanized steel. The original bottom strand of this fence has been renewed, and on the remainder the strands and barbs are pitted and corroded and somewhat reduced in section, but still in service after twelve years on the post.

Conclusions

This Committee is of opinion that the service life of galvanized wire in fences, manufactured and erected in accordance with A.R.E.A. specifications, will average fifteen years, but where exposed to the action of sea water or fumes from industrial plants, service life will average from six to ten years.

From records available and from information obtained through a report as set forth in Farmers Bulletin 239 dealing with "The Corrosion of Fence Wire" following an investigation made by the U.S. Department of Agriculture a number of years ago, the Committee is of the opinion that the use of corrosion resisting metal for the base in fence wire will materially increase the service life of such wire.

Recommendations

This report is submitted as information only and it is recommended that the subject be reassigned for the succeeding year in order that more information may be obtained through the courtesy of the American Society for Testing Materials on the several tests they now have under way and that further information may be had from actual uses.

Appendix D

(4) PERMANENT ROADBED CONSTRUCTION

W. G. Brown, Chairman, Sub-Committee; Paul Chipman, J. N. Grim, Noah Johnson, W. M. Ray, E. M. Smith

Consideration of this subject has been continued from year to year since 1926, and all known installations of such roadbed have been described in previous reports.

Other than observations of user roads on the functioning and maintenance cost data of their respective installations, and a description of the Lehigh Valley's Musconetcong Mountain tunnel section, submitted in this report, the Committee has failed to develop any data of value to add to the reports previously appearing in the Association's Proceedings.

The Lehigh Valley Railroad's permanent track construction consists of 4893.4 ft. double track section through Musconetcong Mountain, in New Jersey, turned over to operation November, 1928, and built in accordance with detailed plan shown on Figure 1, at a cost of \$8.165 per linear foot of track laid. To date the annual maintenance cost has been negligible, while line, surface and drainage is entirely satisfactory. Data concerning tonnage passed is unavailable.

The Michigan Central's Detroit River tunnel tracks, described on pages 219 and 220, Vol. 30, 1929 Proceedings, is considered a special type of construction applicable only to this particular location. Maintenance expense is reported as not unusual, and has so far consisted simply of tie and rail renewals incident to ordinary track operation.

A report from the Track Division of the Board of Transportation, New York City on their permanent roadway (concreted in track) described on pages 605–614, Vol. 31, 1930 Proceedings, indicates the annual maintenance cost as $0.54 per linear foot of track, in comparison with their estimated annual cost of $0.83 for the ordinary ballasted type. This permanent installation has been in service about fifteen years, requiring nothing but rail renewals to date.

The New York Central's installation of permanent roadbed in the vicinity of Staatsburgh, N. Y., referred to on page 232, Vol. 30, 1929 Proceedings, consisting of concrete slabs under two eastbound tracks, was forced upon them by a quicksand subgrade encountered in grade reduction, creating a condition not comparable, for test purposes, with usual track construction, and no tonnage or cost data has been kept.

The Northern Pacific's Point Defiance Line's permanent roadbed construction, described on pages 867–870, Vol. 28, 1927 Proceedings, and pages 601 and 602, Vol. 31, 1930 Proceedings, was built, the Committee learned, for experimental purposes, and as the installations were small, it is not thought original cost figures would be a criterion for similar construction on a larger scale. Maintenance costs have been disappointing and considerably above those on an adjacent track with gravel ballast. The Committee is advised that maintenance, interest and depreciation charges demonstrate this type of construction uneconomical for the traffic density carried, and would not warrant additional installations.

The permanent track section constructed by the Chicago Junction Railway in 1911, mentioned on page 220, Vol. 30, 1929 Proceedings, was replaced by ordinary ballasted track in 1928. The Committee is advised that the permanent construction gave good service until tie renewals were necessary, at which time it became very difficult to maintain good line and surface and exceedingly expensive to replace ties in kind.

The Committee has secured some information regarding the installations of the concrete slabs in the top of the subgrade on the Long Island Railroad, which were described quite fully in a report of the Ballast Committee in 1920 and appearing in Vol. 21, page 447 and Vol. 28, page 863 of the Proceedings, as follows:

Five installations were placed at locations shown below:

"WJ" Interlocking on the Long Island Railroad near Woodside, Jamaica. Slabs were placed under the switches at the throat of the yard.
Float bridges—Bay Ridge.
Float bridge—Long Island City.
Across Juniper Swamp, on New York Connecting Railroad.

The Jamaica installation, about 73,000 square feet, was made in 1912 and 1913 in connection with improvement work at most of the turnouts and slips. Slabs were built of 1-3-6 mix, of Portland cement, sand and gravel, constructed on 21 ft. embankment of sand and gravel. Approximately 1300 daily train movements, including both passenger and freight, pass over this section.

The Woodside installation of 1914 was similarly constructed. The slabs there were placed under tracks located on high fills and have rendered satisfactory service and held track repairs to a minimum. The object of this installation was the study of the performance of such slabs under the existing conditions over a fill, and for the purpose of research have been useful, but hardly considered absolutely necessary at these particular points, as the fill consists of good material which drains readily.

The installations at Bay Ridge and Long Island City float bridges, constructed in 1916 and 1924–1925, respectively, consist of slabs installed at the heel of four float

bridges over an underlying support of old crib and riprap with a silt fill, and handle heavy traffic over switches to and from the float bridges.

Juniper Swamp installation on the New York Connecting Railroad, built in 1917, perhaps gives the best example of the necessity for slab construction under track. This swamp is an old peat bog about 2000 feet long and 70 feet deep in spots, filled with dirt and graded off across the bog for track support. Two spots through this territory were so wet it was found necessary to build two seven inch concrete reinforced slabs, one 100 ft. by 13 ft. and another 150 ft. by 13 ft., with approximately 15 inches of cinder ballast on top. No difficulty has been experienced in maintaining tracks in fair condition over these slabs, and regular speed is made, while on either approach to the slabs it was found more difficult to maintain good line and surface.

No maintenance cost data of these concrete slab constructions as compared with ordinary track, is available.

The following further information is submitted in regard to the Pere Marquette's test sections of concrete roadbed at Beech, Michigan, descriptions and reports of which have appeared from time to time in previous Proceedings:

First Installation

This was placed in operation December 19, 1926, and has been in service nearly five years. The roadbed itself shows no change in condition since the report of a year ago.

It has been found that the amount of rail batter is more noticeable than on ordinary track, due to the rigid support, from which the rail is separated by only a ⅛ in. layer of pressed wood fibre. Enough batter had developed on certain joints to make it desirable that riding quality be improved, and in April, 1931 forty joints out of a total of 68 were built up by the oxy-acetylene process.

New Installation

This section, placed in operation September 20, 1929, remains in the same condition as when built, except that slight surface spalling has occurred at three joints, one more than recorded last year. No cracks have appeared, no appreciable settlement has taken place and no abnormal batter is so far apparent. The method of seating and attaching the rail is entirely satisfactory. Line and surface are unchanged and the track rides very smoothly. The slight feeling of rigidity experienced in riding over the old section is entirely lacking. The use of a ⅞ inch board between the rail and the concrete in the new design has been sufficient to overcome this feature, and yet permits so little deflection in the rail that rail wave is almost eliminated.

The cost of maintaining the Pere Marquette's concrete roadbed at Beech, Michigan, during the year August 1, 1930 to July 31, 1931, is reported to have been as follows:

First Installation:

Labor tightening bolts, taking up expansion and replacing clips and broken bolts	$ 35.74
Restoring battered rail ends, 41 at $1.86	76.26
	$112.00

New Installation:

Tightening bolts, 15 hours at $0.45	$ 6.75

This section is 390 ft. long. At this rate, maintenance on one quarter mile would be $22.85.

Ordinary Roadbed:

On the nearby one quarter mile section of ordinary track on which comparison has heretofore been made, the cost of maintenance was as follows:

Labor		
Lining and surfacing	$ 40.58	
Making grass line	15.40	
Renewing ties	25.33	
Tightening bolts and tapping down spikes	14.62	95.93
Material		
63 ties at $1.94	122.22	
Spikes	2.20	124.42
		$220.35

The report is offered as information with the recommendation that the subject be discontinued for a time pending results from longer service of the various installations now on record.

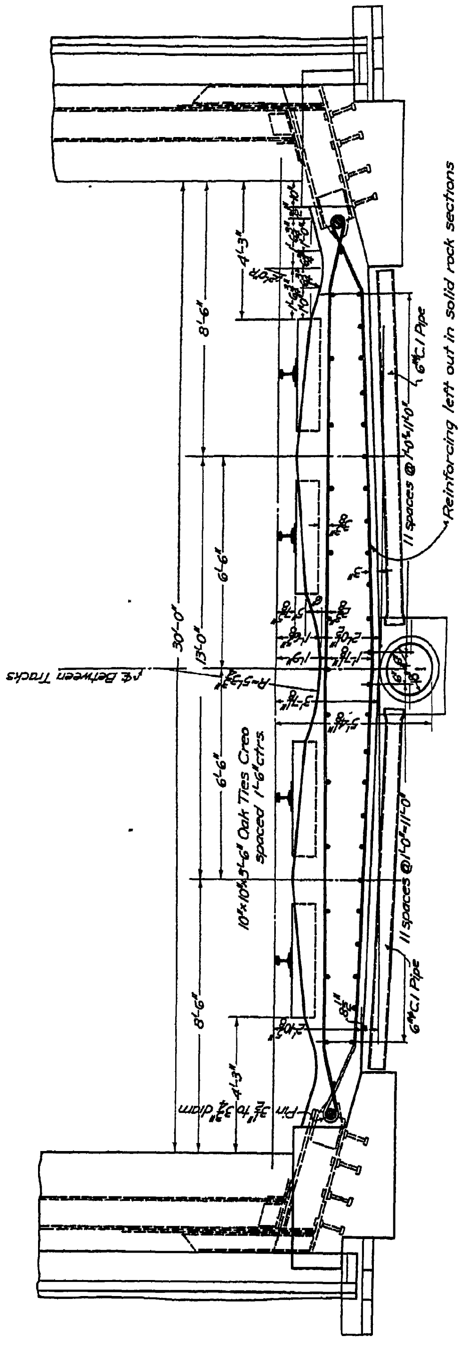


FIG. 1.

Section of Concrete Roadbed Used in Musconetcong Mountain Tunnel, Lehigh Valley Railroad

Appendix E

(5) SPECIFICATIONS FOR OVERHAUL IN GRADING CONTRACTS AND A RECOMMENDED METHOD FOR CALCULATING OVERHAUL

C. W. Baldridge, Chairman, Sub-Committee; T. A. Burgess, Daniel Hillman, R. M. Jolley, E. R. Lewis, R. J. Middleton, Jamison Vawter

In a revision of the 1925 Manual, made in 1926, an optional Overhaul Clause, contained in the specifications for the formation of the Roadway, was, by vote of the Committee, eliminated. Later a canvass of a considerable number of the railways was made and returns indicate that a sufficient use is made of overhaul clauses in grading contracts to make it advisable to again submit a specification for overhaul and details of a method for calculation of overhaul.

Your Committee, therefore, submits the following which they recommend be adopted for inclusion in the Manual, to be inserted as Item No. 50 of "Specifications for the Formation of the Roadway", following Item 49 on page 34 of the 1929 Manual.

SPECIFICATIONS

Haul

(50) Unless otherwise specified, the contract price per cubic yard covers all haul which may be necessary. When an allowance for overhaul is provided for in the contract, it shall be handled as follows:

(a) The overhaul shall be calculated in the unit of one cubic yard, measured in excavation, moved one hundred feet.

No overhaul shall accrue until the material must be transported a distance exceeding the free-haul limit as provided in the contract, and on such material overhaul accrues as follows:

"All material hauled—A B C—(distance provided in contract) feet or less shall be paid for at the flat rate of—X—cents per yard. Overhaul of—Y—cents per yard per each one hundred (100) feet hauled over the—A B C—feet of free haul and up to—D E F—hundred feet of haul will be paid in addition to the flat rate as provided above. For material hauled over—D E F—hundred feet the overhaul shall be the same as for the material handled—D E F—hundred feet."

Or the rate may be made as "the same as for material hauled—D E F—hundred feet plus—Z—cents per yard per one hundred feet hauled over that distance."

Distance hauled shall be the one-way distance along the center line of the grade, except where the fill is being made from a borrow pit, approved by the Engineer in charge of the work, or where for any approved reason the material excavated from the cut is being used or wasted at a location other than in the fills being made for the roadbed. In such cases the overhaul shall be computed along the most direct way which it is practicable to haul the material.

Overhaul shall be measured for the movement of loaded equipment only.

METHOD OF COMPUTING OVERHAUL

After completion of the grade, the amount of overhaul shall be computed by means of a graphical figure platted as follows:

The grade point on the center line (or base line) of the grade shall be taken as the zero point of the graph, and the amounts of excavation and of fill, as determining the overhaul.

Using profile paper and making the grade point the apex, plat the amount of excavation from zero point to the first station in the cut, continuing at each station platting downward the sum from zero to that station. Again from the zero point as apex,

plat the summation of fill at each station, also downward. Any allowance required for swell or shrinkage of material shall be made by deducting or adding in the summation figures for embankment before platting.

With fine lines connect the points platted and a graph is produced, the horizontal distances of which represent the length of the hauls and the drawn lines represent the cubic yards of material handled to any point in the line.

By using an Engineer's scale held horizontal (parallel with the lines on the profile paper) the distance representing the free haul limit is first measured, and the number of cubic yards represented by the graph line gives the amount of material within the free haul limits. Moving the scale down until the next 100 feet represented by the scale is reached and the cubic yards read from the graph, less the cubic yards at the free haul limit, gives the number of yards on which fifty feet of haul is due. Again moving the scale down until another 100 feet of distance is indicated and again reading the total yardage indicated by the graph, the number of yards overhauled one hundred and fifty feet is found, etc.

If the excavation is heavier than the fill, or vice versa, the graph takes care of the difference by a steeper slope on the heavier side and a flatter slope on the light work side. If a bridge must be crossed, where no material is to be used, the graph becomes a straight horizontal line for the length of the bridge, thus measuring the increased haul.

Errors in reading the graph cannot become very great since the actual yardage is known at each station point, and the lines on the paper make it easy to keep the scale horizontal. Such errors in reading as do occur are taken care of in the next reading and should balance as the work goes on.

Using the excavation and fill measurements in the following pages from a construction notebook and platting them on profile paper, gives an example of the determination of overhaul (see Fig. 1 and 2).

Station	*Elevation*	*Cubic Yards*		*Summation of Totals*	*Fill Quantities Adjusted for 50 per cent swell of Excavation*
860	663.8				
		549		24 122	16 082
861	664.0				
		522		23 573	15 714
862	664.2				
		497		23 051	15 368
863	664.4				
		459		22 554	15 036
864	664.8				
		409		22 095	14 730
865	665.3				
		307		21 686	14 456
866	666.4				
		178	145	21 379	14 252
867	667.8			98	
		63		65	
868	669.0				
		2	Fill	2	
868x10					
		6	Exca.	6	
869	669.6				
		38		44	
870	669.9				
				98	

Station	*Elevation*	*Cubic Yards*		*Summation of Totals*	*Fill Quantities Adjusted for 50 per cent swell of Excavation*
871	570.0				
		54		98	
872	669.9				
		56		109	
873	669.5				
		38		53	
874	669.3				
		15	Exca.	15	
874x05					
		220	Fill $\frac{109}{111}$	21 234	14 156
		122		21 123	14 082
876	667.0				
		397		21 001	14 000
877	663.3				
		948		20 604	13 736
878	659.2				
		1 607		19 656	13 104
879	656.2				
		2 337		18 049	12 032
880	653.6				
		2 917		15 712	10 474
881	651.6				
		3 271		12 795	8 530
882	650.0				
		3 188		9 524	6 350
883	652.2				
		2 482		6 336	4 224
884	655.4				
		1 735		3 854	2 570
885	658.7				
		1 152		2 119	1 412
886	661.6				
		630		967	644
887	665.2				
		272		337	224
888	667.6				
		65	Fill	65	44
888x91	669.4				
		1	Exca.	1	
889	669.5				
		38		39	
890	670.3				
		124		163	
891	671.4				
		219		382	
892	672.4				
		330		712	
893	673.5				
		459		1 171	
894	674.5				
		575		1 746	
895	675.3				
		701		2 447	
896	676.2				
		821		3 268	

Station	Elevation	Cubic Yards	Summation of Totals	Fill Quantities Adjusted for 50 per cent swell of Excavation
897	677.0			
		940	4 208	
898	677.8			
		1 048	5 256	
899	678.4			
		1 169	6 425	
900	679.1			
		1 241	7 666	
901	679.3			
		1 276	8 942	
902	679.4			
		1 290	10 232	
903	679.5			
		1 276	11 508	
904	679.4			
		1 241	12 749	
905	679.3			
		1 259	14 008	
906	679.4			
		1 278	15 286	
907	679.4			
		1 259	16 545	
908	679.3			
		1 233	17 778	
909	679.2			
		1 223	19 001	
910	679.2			
		1 223	20 221	
911	679.2			
		1 223	21 447	
912	679.2			
		1 223	22 670	
913	679.2			
		1 215	23 885	
914	679.1			
		1 187	25 072	
915	678.9			
		1 151	26 223	
916	678.7			
		1 108	27 331	
917	678.4			
		1 052	28 383	
918	678.2			
		1 021	29 404	
919	678.1			
		1 005	30 409	
920	678.0			
		1 018	31 427	
921	678.3			
		1 056	Hauled opposite direction	

In the example the graph is produced by platting the stations at 400 feet to the inch horizontal, as is customary on profiles and the yards of excavation and fill are platted vertically at 4000 yards per inch.

The overhaul is then determined by measuring from the excavation line to the fill line, on the graph, the free haul distance (in this case assumed as 500 feet).

In this case where the two lines are 500 feet apart, we find the yardage of material handled to be 380 cubic yards. At 600 feet apart the yardage reads 564. The difference between these two readings is 184 which gives the number of cubic yards hauled fifty feet over the free haul. At 700 feet the yards handled total 750, amounting to 186 yards more than at 600, thus showing 186 yards on which 150 feet of overhaul must be paid. Repeating this performance at each added 100 feet will give the total overhaul for the location.

If it is desired to keep notes of the calculations for the purpose of checking the work or for any other reason, they may be made up as follows:

Distance	*Total Yards*	*Overhaul Yards*	*Length of Haul*	*Overhaul*
500	380	0	0	0
600	564	184	50	92
700	750	186	150	279
800	1026	276	250	690
900	1400	374	350	1309
1000	1830	430	450	1935
1100	2360	530	550	2915

etc.

"Excavation" calculations must be continued to the point where the material was hauled in the opposite direction or to the end of the cut.

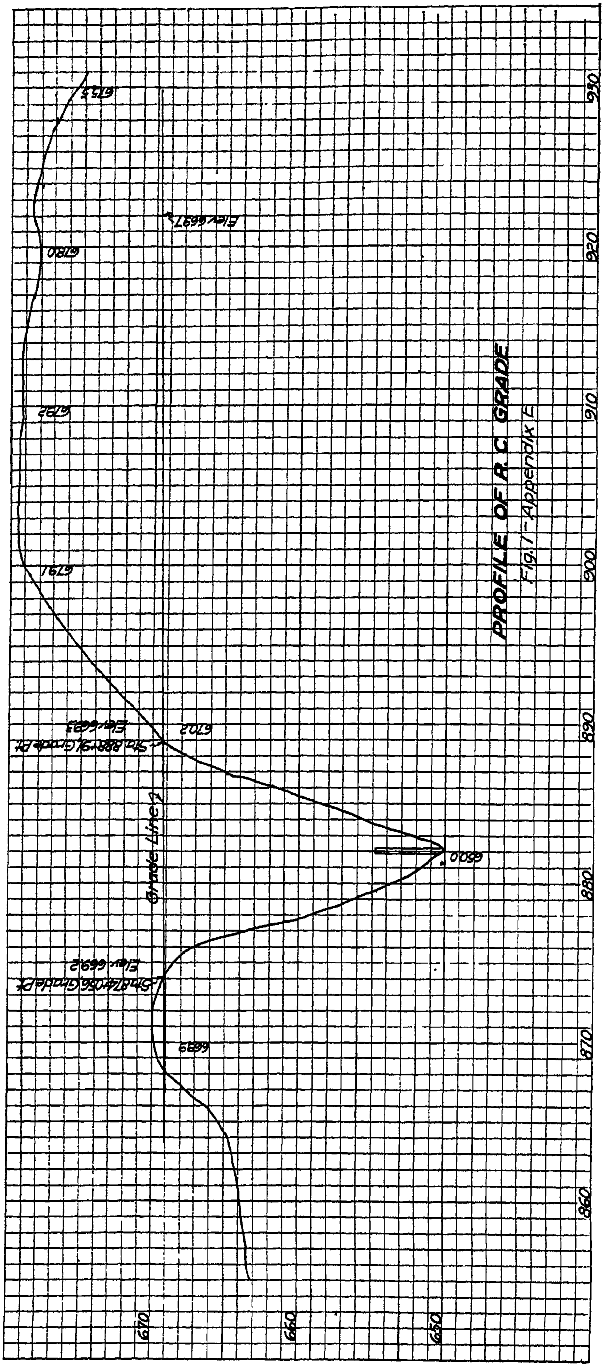
The "fill" calculations must be carried to the furthest point to which the material is hauled, except when the overhaul contract is so written as to provide for a maximum allowance for haul. In such cases the platting of the quantities may cease at the point where the flat rate for overhaul begins.

Note (a)—

The vertical scale used in the illustration herewith uses a larger number of cubic yards per inch than is desirable in practice. This was done to keep the plat within a suitable size for illustration.

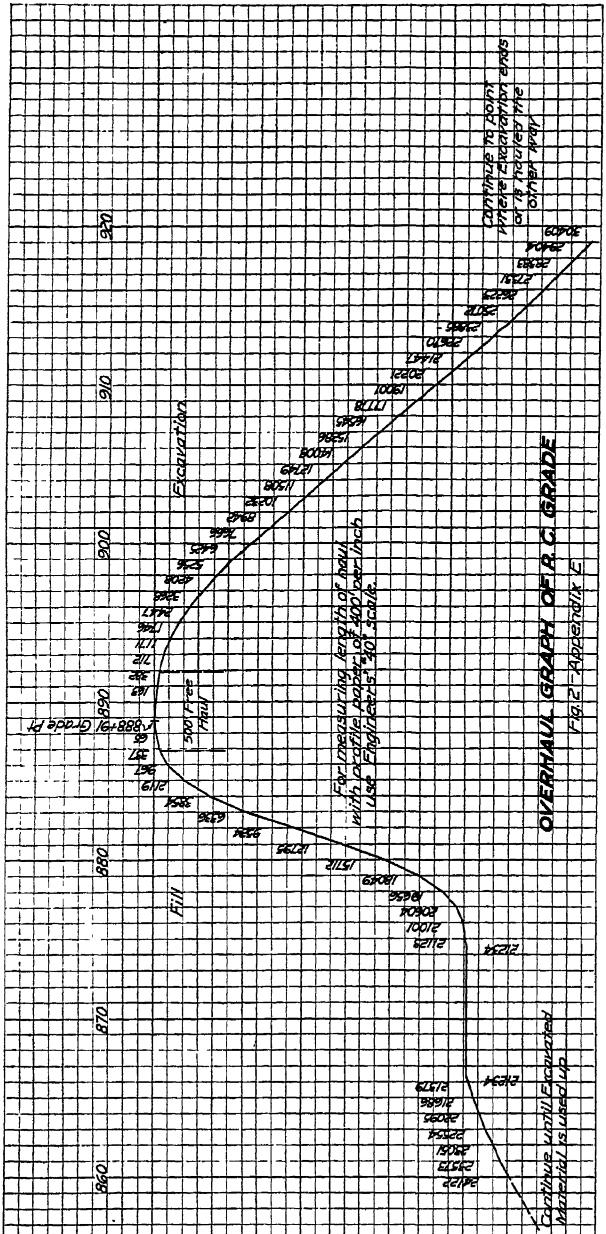
Note (b)—

The platted lines used are much coarser than is desirable in practice to permit of photographic reduction for illustration.



PROFILE OF R. C. GRADE

Fig. 1—Appendix E



OVERHAUL GRAPH OF B.C. GRADE

Fig. 2—Appendix E

Appendix F

(8) USE OF HIGHWAY CROSSING PLANKS AND SUBSTITUTES THEREFOR

E. C. Oyler, Chairman, Sub-Committee; L. C. Frohman, J. A. Given, J. N. Grim, F. W. Hillman, Noah Johnson, R. M. Jolley

The activities of our Committee have been confined this year to the collection, shown below, of additional installation and maintenance cost data as well as the securing of data covering life studies, it being felt that until more information is available the relative merits of plank and substitutes therefor cannot be determined.

Location of R.R.	*Kind of Crossing*	*First Cost Per Track ft.*	*Annual Maintenance Costs, Excluding Depreciation Per track ft.*	*Estimated Life in Years*	*Remarks*
East	Plank:				
	Treated Gum:				
	1 Track	$3.90	$0.30	6	
	2 Tracks	5.50	0.45	6	
	Untreated Y. P.:				
	1 Track	2.60	0.30	4	
	2 Tracks	4.10	0.45	4	
	Bituminous:				
	1 Track	2.65	0.20	7	
	2 Tracks	3.60	0.23	7	
	Concrete Slabs:				
	2 Tracks	11.34	0.05	15	
East	Plank:				
	Treated	5.00	0.15	8	
	Untreated	4.00	0.30	4	
	Bituminous	2.75	0.20	10	
East	Plank:				
	Treated Gum	6.25	0.18	10	
	Untreated Oak	5.74	0.18	8	
	Untreated Pine	6.12	0.18	6	
	Natural Rock Asphalt	5.68	0.12	12	
	Bituminous	4.51	0.25	4	
	Concrete—Solid	5.56	0.10	15	
	Concrete — Pre-cast slabs	9.93	0.10	15	
Middle West	Natural Rock Asphalt —Includes flangeway rail and timber headers	$2.24	$0.245		Installed 1925. Repaired in 1927, 1929 and 1931.
Middle West	Bituminous—Excludes cost of flangeway rail but includes timber headers	2.84	0.188		Installed 1926. Resurfaced 1927 and repaired 1931.
Middle West	Bituminous—Includes flangeway rail, rail supports and timber headers	2.68			Installed 1930. No maintenance charges to date.

Location of R. R.	*Kind of Crossing*	*First Cost Per Track ft.*	*Annual Maintenance Costs, Excluding Depreciation Per track ft.*	*Estimated Life in Years*	*Remarks*
Middle West	Concrete slab	7.88			Installed 1927. Practically no maintenance charges to date.
Middle West	Concrete slab	6.92			Installed 1928. Practically no maintenance charges to date.
Middle West	Built up timber slab..	10.32	1.13		Installed 1924 and repaired in 1927, 1928, 1929 and 1931.
Middle West	Cast metal unit	19.95			Installed 1928. No expense to R. R. Co. to date.
Middle West	Premixed Bituminous. 3 in. thick on crushed stone base. Includes flangeway rail and timber headers	2.65			
West	Plank: Untreated ...	2.50	0.25	4	
West	Natural Rock Asphalt. Includes flangeway rail	4.74	0.05	10	
West	Cold Patch Bituminous	3.12			Generally Unsatisfactory.
West	Asphalt Plank — Includes flangeway rail and creosoted filler plank	10.73	0.05	10	
West	Cast metal unit	14.60	0.05	20	
West	Rail Type	8.40	0.05	20	
South East	Natural Rock Asphalt	3.0			6–2 Track Crossings. 785 sq. yds. Cost per sq. yd. $1.90. After 4 yrs. service 4 of the crossings are in poor condition, other 2 being in fair condition.

A

Location of R. R.	Kind of Crossing	First Cost Per Track ft.	Annual Maintenance Costs, Excluding Depreciation Per track ft.	Estimated Life in Years	Remarks
South East	Natural Rock Asphalt with flangeways	5.10			3–2 Track crossings. 223 sq. yds. Cost $4.15 per sq. yd. Two of the crossings have 3 yrs. service, one being in good and the other in poor condition, the 3rd crossing having 4 yrs. service being in fair condition.
South East	Bituminous Manufactured Product of graded rock or gravel and asphalt 1½ in. to 2 in. thick laid on water bound native limestone base	3.74			2–2 track, 1–3 track and 1–4 track crossing. 416 sq. yds. Cost per sq. yd. $3.12. After 3 years service 2 crossings are in good and 2 in fair condition.
South East	Bituminous Manufactured Product of graded sand and asphalt or asphalt base oils 1½ in. to 2 in. thick laid on water bound native limestone base	5.13			1–2 track and 1–3 track crossing, 470 sq. yds. Cost per sq. yd. $1.87. After 3 yrs. service one is in fair and the other in poor condition.
South East	Bituminous Manufactured Product of graded rock screenings, selected sand "Cut Back" asphalt 1½ in. to 2 in. thick laid on water bound native limestone base	1.94			1–2 track and 1–3 track crossing, 249 sq. yds. Cost per sq. yd. $1.48. After 6 months service one crossing is in good condition and after 1½ yrs. service the other is in fair condition.
South East	Plank—Cypress	3.47			1–2 track and 2–1 track crossings, 191 sq. yds. Cost per sq. yd. $2.40. 2 of the crossings are in good condition after 8 and 4 yrs. service respectively, the 3rd having been removed due to City paving program in 1926 after 3 years service with no repairs.

This report is offered as information, with a recommendation that the subject be continued.

Appendix G

(10) MEANS OF PROTECTING ROADBED AND BRIDGES FROM WASHOUTS AND FLOODS

H. M. Swope, Chairman, Sub-Committee; F. W. Hillman, G. E. Ladd, L. C. Frohman, H. W. Legro, J. A. Noble, P. T. Simons, O. H. Wainscott, L. J. Drumeller

To avoid conflicting with the work of Committee XXV—Rivers and Harbors, the work of this Committee on the above subject is confined to streams which are not classed as navigable and to conditions which may cause the flooding of railway tracks.

An outline of the work which the Committee endeavors to cover is as follows:

OUTLINE

SCOPE
Importance:

I. Permanent Protection

1. BRIDGES
   - (a) Sufficient waterway.
     - Length
     - Approach openings
   - (b) Relations of character of materials to water erosion.
   - (c) Depths of foundation and protection from scour.
   - (d) Prevention against stream erosion threatening new channels around bridges.
   - (e) Protection at ends of boxes and culverts.
   - (f) Protection for head of bank in trestles and trestle approaches.
   - (g) Drift catchers.
   - (h) Levees to collect water and confine to bridge openings.
2. FILLS
   - (a) Sufficient overflow openings.
   - (b) Anchoring track.
   - (c) Protection of embankment subject to overflow.
   - (d) Wave action.
   - (e) Flow of water through fills.
   - (f) Side washes.
     - Streams
     - Surface Ditches

II. Temporary Protection

1. BRIDGES AND CULVERTS
   - (a) Sand bags, etc.
   - (b) Drift.
2. FILLS
   - (a) Side washes.
   - (b) Erosion in overflow.
   - (c) Wave action.

Scope

This subject has to do with the protection of the roadbed and bridges from washouts and floods, including protection of both a permanent and temporary nature.

Importance

The necessity for adequate protection against washouts and floods is obvious for the preservation of both life and property and the maintenance of uninterrupted service. Heavy expenditures of money to replace damaged property due to this action of the elements, emphasizes the need for and the possibilities of further protection against this economic waste.

(I) PERMANENT PROTECTION

1. Bridges

(a) Bridges and openings should have sufficient waterway to prevent overflow and scour due to excessive head. Care must be taken in bridge design, more especially in overflow bridges to secure sufficient length of opening to hold the heading effect of flood waters to a minimum. This is necessary to reduce rapid velocities which result in scour or cutting back of bulkheads where trestles are involved, minimizes possibility of overflowing track with resulting wash due to different elevations of water planes above and below track, as well as eliminating possible claims for damage to adjacent property insofar as possible.

If the condition exists in which culverts operate under head, the wing walls and headwalls should extend above extreme high water where practicable and the adjoining embankment protected with riprap or concrete blanket well toed in below scour line. The outlet should be paved and amply protected with toe wall and the wings flared to prevent wash from swift velocities. Care should be taken that this heading effect does not damage valuable land for which the railway company would be liable for damages. The practice of designing openings to discharge under head is not recommended. On less important branch lines, it may be economical not to consider the extreme high water in the design, as in some instances the saving in construction costs may more than off-set the cost of repairs due to occasional extreme floods.

Trestles and trestle approaches to spans should, where practicable, extend to a point where the required fill is low to prevent high bulkheads, thus reducing the hazard of water cutting behind bulkheads. Maintenance expense will also be reduced by reduction in bank pressures, and in stabilizing shoulders at the ends of bridges. In construction it is recommended that the head of bank slope be not steeper than 2 to 1, starting from a level plane, which is 6 in. below the bottom of the cap, at a point not less than 5 feet in front of the face of the dump bent.

(b) It is important in the study of prevention of scour to analyze the soil and material involved in determining the type and degree of protection necessary. Sands and soils which are easily disintegrated by water, are obviously more susceptible to erosion than clays, rock, etc., and require more extensive protection.

In some instances where the stability of foundations are questionable and unknown it is necessary to determine the nature of the backfilled material around the masonry and the material underlying the foundation itself. This can usually be accomplished by soundings or excavations.

(c) Foundation design and the bearing power of soils are not within the scope of this report, but it should be emphasized that foundations and piling penetration should be carried sufficiently below the possible depth of scour produced under adverse conditions. Drift, ice, washed out highway bridges, buildings and other debris lodging in bridges cause heading of flood waters and strong currents and eddies with severe scouring effect. In many streams during floods, scour will extend to rock or shale and piling resting on such hard strata is not secure, although during normal water they may have a penetration of 15 feet or more in sand. In these instances, the stability of the bridge can be materially improved by placing riprap or heavy rock around the piling. This will sink through the erodible bed during rises and finally rest on stable footing. The same procedure is applicable to pile piers and to masonry foundation where scour may gradually cut away the harder foundation material or reaches the bottom of masonry resting on piles, or similar foundations. Where the current velocity is swift, riprap will not lie in place and it will be necessary to confine it within an enclosure of sheet piling, concrete wall or crib, placed during periods of low water and extending to solid footing or well below scour as the case may be.

In designing bridges for locations where channel slopes are steep, or are not uniform, and the stream bed is friable, careful examination should be made to be sure progressive cutting up stream and lowering of the channel will not endanger footings. If this is not done, costly protection works may become necessary.

Sufficient length and proper angle of wings are essential in abutment design and subdrainage back of abutments should be provided to prevent slides during high water and saturation periods. Additional protection of riprap, derrick stone, retaining walls or con-

crete blankets should be considered in protecting fills at abutments when subjected to strong currents or eddies. Ice jams should be broken up; drift removed and not permitted to collect at piers or pile bents on account of the damming and scouring effect, as well as the pressure produced. Falsework piling, after it has been removed, should be kept cut flush with, or below, bed of stream, where practicable, to prevent the stoppage of drift.

(d) Where stream erosion threatens to cut new channels around bridges or serious shifting of channel occurs, corrective measures should be undertaken by means of channel control, such as channel changes, revetments, retards, dikes, riprap, blankets and other similar protection works, or a combination of the above. This is necessary to keep the channel and flow of water directly to and from the bridge opening, eliminating all possible eddies, cross currents and flow restrictions tending to produce scour, silting and heading of waters.

(e) Possibilities of abnormal heavy and highly concentrated rainfall make it advisable to give consideration of protection at small openings not only in providing sufficient waterway, but by the use of riprap, walls, blankets or other materials with high resisting power to wash to prevent erosion of the embankment. Quite often spillways are necessary to prevent scour at the lower end of culverts. Openings of this nature are subject to temporary clogging due to debris which may cause overflow, fouling of ballast and cutting of the roadbed. The blanketing of embankment subject to wash at these small openings is recommended. When concrete boxes, pipes or wooden boxes are used in precipitous slopes, it is usually necessary to protect the outlet and sometimes also the inlet. With concrete boxes and sometimes with pipes, concrete extensions consisting of headwall and wing walls with floor and toe wall of sufficient depth are necessary. This type of protection is preferable for reinforced concrete boxes, but is not desirable for use with pipe culverts since the bank pressure against the head walls tends to pull the pipes apart. If protection is desired for pipes and wooden boxes, grouted riprap toed in below scour line is usually preferable, but should not be used for the purpose of shortening the length of the culvert. Where the slopes are flat, if the openings are of sufficient length, this protection may frequently be omitted. It is sometimes necessary to provide concrete or masonry underpinning to existing floors, especially spillways to prevent undercutting. Waterways carrying drift and debris should be provided with clear openings to minimize its lodging.

(f) Pile trestles and trestle approaches subject to erosion producing currents during high water should have the head of bank protected for a minimum distance of 10 feet back of bulkheads with concrete blanket or riprap, either plain or grouted. The type of protection to be used depends upon the importance of the facility to protect, degree of current, erosion resistance of the material in the embankment, etc. In the construction of embankments, the best materials that are available should be selected. This is especially important back of bulkheads and abutments.

(g) Drift catchers are not generally recommended due to the costly maintenance in removing drift and the tendency to neglect this essential. It is best to provide sufficient clear waterway to permit unrestricted passage of drift where practicable. At bridges where drift trouble can be expected, more particularly in the case of pile trestles, the drift should be guided past the opening by men with the aid of pike poles. Where necessary to provide drift catchers, they can be constructed by using well braced woven wire fence above the smaller openings and by driving a row of piling or rails above the larger openings. Secondhand rails are preferred on account of the probability of burning the accumulated drift. Care should be taken to have these catchers located a sufficient distance above the bridge to assure proper entrance for the water into the opening, and for the protection of the structure if the drift is fired.

(h) Levees to collect water and confine it to bridge openings will be found advantageous in many cases, but are particularly applicable to situations where the railway lies in and near the edge of an alluvial or mountain valley whose tributaries have steep slopes. Under such conditions, these tributaries during flood stage emerge from the hills at high velocity carrying a heavy load of sediment, a large portion of which is dropped as the slope suddenly flattens. This results in the building up of a delta cone at the points where such streams emerge into the flood plain and high water spreads fanwise over a front of hundreds or, in some cases, thousands of feet. Due to the delta cone mentioned, the highest ground in the vicinity is usually opposite the mouth of the

stream and the railway will be on a comparatively low fill, the height of which will increase in either direction from the summit. Under these circumstances, a low levee parallel, or with a slight angle to the track will guide the flow to a point where sufficient head room can be obtained for a bridge. Local conditions will govern in designing the levee, but usually one ranging from four to six feet high with a six foot crown and two to one slope will suffice. Riprap is seldom necessary as in the regions where this type of construction is of the most value, rainfall occurs at infrequent intervals and water seldom remains long enough to soften the face of the levee and erode it to any great extent. In locations where the material is of fine sand or similar highly erodible material, consideration for the placing of riprap or concrete blanket well toed in should be given. It is sometimes feasible to eliminate the delta forming process by the construction of a spillway or dam, or a series of such dams, through and above the head of the cone, and also by the widening of the channel, to reduce the erosion producing velocity.

2. Fills

(a) In overflow territories, careful investigation is necessary to see that the required waterway is provided. The openings should be sufficiently long to minimize heading during floods, which is occasionally the basis of damage suits and is the type of overflow when flowing over the embankment that causes excessive damage due to the water-fall effect producing strong erosion currents. In overflow bottoms, it is practically impossible to overcome all of this heading and where it is not practicable to raise grade above the high water plane, various forms of protection can be made. It is well to call attention to the fact that overflow of the embankment does not always occur at bridges but may overflow where the track crosses either side of the valley, and in some instances at a remote distance from the bridge, especially when the track is located in and parallel with the valley.

(b) At locations where track washes off of the roadbed, it can be anchored by driving *16 to 20 ft. T-rails* or piling and tying to the track by use of copperweld twisted strand wire and clamps. In non-automatic signal territory the twisted strand can be looped around the rail seating on the tie. In automatic territory the track should be tied to the anchors by the use of large eye screws or eye bolts placed in or through a sound tie midway between the rail and the end. The anchors should be spaced from 50 to 100 feet center to center, depending upon severity of wash. When tracks are subjected to both direct and back wash, it may be necessary to anchor for both directions. In multiple tracks, the lower track should be anchored as described above and ballast should be filled level approximately to the top of ties between tracks. In some cases, it may be necessary to anchor the upper tracks. If so, the spacing of anchors may usually be approximately three times greater than that of the lower track. In these locations rock or like ballast should be used in preference to lighter material. If the track is carried on a fill exceeding two or three feet, the shoulder on the lower side should be protected as described in the following paragraph; otherwise, the anchored track may cause acceleration of the cutting after it has once started.

(c) When conditions justify, protection of embankment can be accomplished by the use of riprap. The shoulder subject to wash should be faced with plain or grouted riprap built up from sub-grade to an elevation of top of tie or 3 or 4 inches above and extending from 6 in. to 12 in. from the ends of ties to the shoulder; thence down the slope to a point four feet or more vertically distant below the water surface when at the stage of beginning of overflow. The riprap stone should be heavy and of such shape that it will not easily roll. The lower edge of the riprap blanket should be well toed into fill.

(d) The general and most economical method of permanently protecting fills against wave action is through the medium of riprap or the widening of the embankment with loose rock or shale. In territories where climatic conditions permit, erosion to embankment by the action of moderate waves or current may be successfully controlled with willows by the pole planting process, cutting them back to maintain a dense growth.

(e) Flow of water through fills creates a hazard and is commonly caused by the borings of groundhogs, gophers and like rodents. These animals can be exterminated by poison, the methods for which can usually be secured from the State Agricultural colleges in the localities affected. Another successful method for eliminating such animals

is to conduct the exhaust gases from a gasoline engine into the holes and forcing it into the dens. The stoppage of leaks through gopher and other holes can be accomplished by filling with clay which should be thoroughly tamped as placed. Flow of water through pervious embankments can be corrected by coating the upper side of the embankment with clay.

(f) Where the embankment or roadbed is endangered through side wash from streams, first consideration should be given to channel relocation, track line change or channel control through the use of revetments, retards, dikes or similar agencies. Where this treatment is not practicable, or does not wholly accomplish protection during high stages, then riprap, concrete blanket, brush and rock mattress, willow planting, or similar protection should be provided. Under some conditions, as with overflow water courses where the channel is not well defined or permanent, earthen levees protected with riprap or blankets throughout their entire length, or at the ends only, can be effectively used by winging them out from one or both ends of the bridge.

Side wash resulting from parallel or encroaching ditches are best corrected by relocating the ditches at a desirable distance from the track. Where this procedure is not practicable, the wash can be retarded by the means of riprap and in some cases it can be corrected by the construction of brush, timber, rock or wire dams. These washes often make a desirable location for the dumping of scrap wire, tin, batts and other debris having erosion resisting qualities.

(II) TEMPORARY PROTECTION

Temporary protection usually calls forth all of the resourcefulness of the engineer. It is mostly made in emergency during floods or when rises are expected that may endanger the railroad property.

1. Bridges

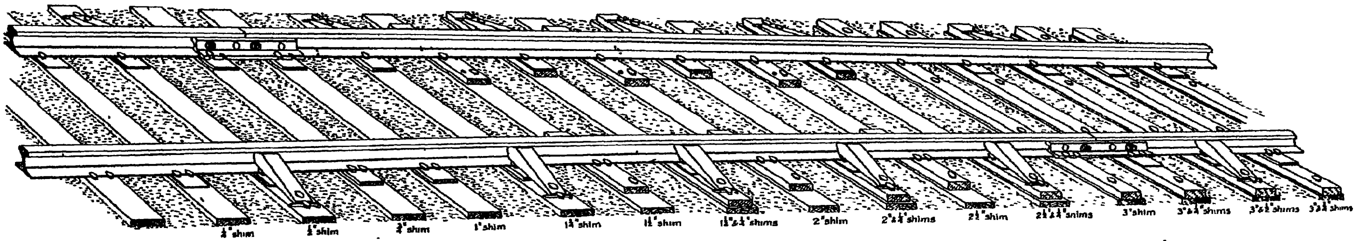
(a) The "sand bag" is probably the most common agency used in protecting embankments from wash, as usually they are readily obtainable. Bags should be kept available for territories where damage to track from high water occurs at frequent intervals. They can usually be procured from milling companies on short notice. The bags can be filled with sand, ballast, chatts, screenings, gravel, or like material, and if company material is not available, often commercial shipments can be confiscated, in which case, prompt notice should be given to the shipper to avoid unnecessary delay in refilling the order. In many territories, the soil is sandy and will make good filling material. If none of the above is available, the bags will have to be filled with the best material that can be obtained. Brush tied with wire or cable in round bundles with one-man size rock in the middle as a core is easily prepared. They should be securely anchored and are effective in side washes, bank cutting and other similar situations.

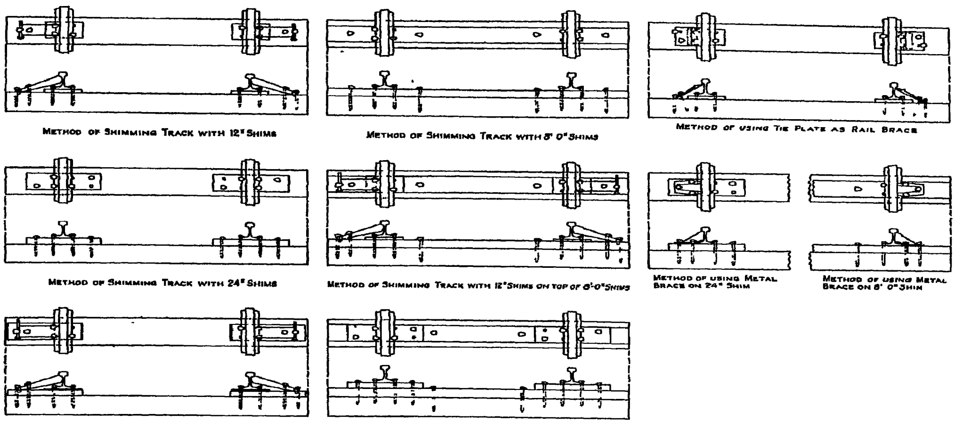
(b) The usual damage occurring to bridges during high water is in cutting back of bulkheads, cutting of embankment at abutments due to eddies and cross currents, scour and the accumulation of drift or ice which causes heading of water and scour. Drift or ice may accumulate to the extent that sufficient pressure is exerted to cause the loss of the bridge. The wash at the ends of bridges can best be combated through the use of sand bags, brush bundles, riprap, mine shale or any erosion resisting material available. Where drift accumulates, it should be dislodged and guided through the opening with pike poles, if possible. Every possible effort should be made to keep bridges free from drift and the jamming of ice during high water.

2. Fills

(a) Fills subject to wash and cutting banks can best be protected quickly with anchored brush bundles where the current is swift. A blanket composed of a layer of "sand bags" between two layers of mesh wire, the wire being tied together at intervals, is effective in swift water if the slope is not too steep. In some instances, time may permit the sloping of the bank if necessary. Riprap, "sand bags", mine shale and like materials are effective where the current will not wash it out of place. Sluffing and slides are usually the most severe when the water recedes, as the embankment or bank is saturated, thus flattening the angle of repose.

(b) In the overflow of embankment, from either direct flow or back wash, there is generally a decided differential in elevations of the water planes above and below the track which causes wash on the side having the lower water plane. The quickest and





Method of Shimming Track with 12" Shims

Method of Shimming Track with 8' 0" Shims

Method of using Tie Plate as Rail Brace

Method of Shimming Track with 24" Shims

Method of Shimming Track with 12" Shims on top of 8'-0" Shims

Method of using Metal Brace on 24" Shim

Method of using Metal Brace on 8' 0" Shim

Method of Shimming Track with 12" Shims on top of 24" Shims

Method of Shimming Track with 24" Shims on top of 8' 0" Shims

Scale

For plan showing Standard method of Shimming Track where track is tieplated, see plan No R12C-2-1

NOTES

Note particularly Maintenance of Way Rules 32, 243, 244, 245, 286 to 299 inclusive

Notwithstanding Rule 288 all shimmed track should be braced except where 24" and 8 foot shims are used and which are spiked to the ties independently of the rail spikes as shown on this drawing

With regard Rules 244 and 294, in future 8 foot long shims will be furnished instead of 7 foot long shims

Where 12" shims are used, rail braces shall always be used as follows:

On tangents and curves up to 1 degree use at least 5 pairs of rail braces per rail length, evenly spaced, one pair to a tie

On curves over 1° up to 4 degrees use at least 6 pairs of rail braces per rail length, evenly spaced, one pair to a tie

On curves over 4° up to 6 degrees use at least 8 pairs of rail braces per rail length, evenly spaced, one pair to a tie

On curves over 6 degrees use at least 10 pairs of rail braces per rail length, evenly spaced, one pair to a tie

Where rail braces are used, they shall always be placed in pairs, one on each end of the same tie

24" and 8 foot shims shall always be spiked to the tie as shown on plan, in addition to the spiking of the rail

Where 24" or 8 foot shims are used by themselves it is not generally necessary to use rail braces, but if 12" shims are used on top of the 24" or 8 foot shims then rail braces shall be used

Standard wooden rail braces should always be used but if these are not available, other means of bracing must be adopted to keep the track safe. It is permissible to use tie plates 10" or 10½" long where standard wooden braces are not available, but shorter tie plates should not be used

With regard Rule 292 the "Standard Rail Brace" referred to is a standard steel or iron rail brace

IN SHIMMING TRACK USE SHIMMING SPIKES

Not less than three spikes per rail per tie shall be used for shimmed track as follows:

Where the track is tieplated, two spikes shall be used on the inside of the rail and one on the outside

Where the track is not tieplated, two spikes shall be used on the outside of the rail and one on the inside

CANADIAN NATIONAL RAILWAYS
STANDARD
METHOD OF SHIMMING TRACK
WHERE TRACK IS NOT TIEPLATED

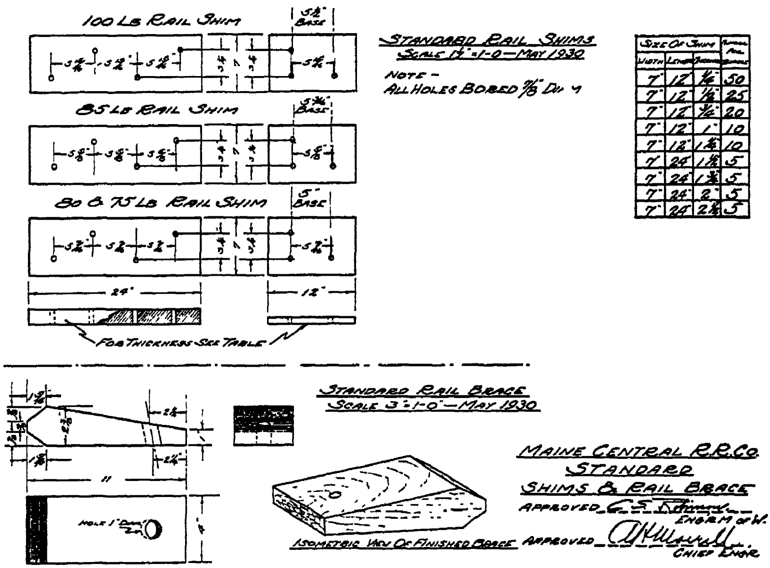
MONTREAL

OFFICE OF ENGINEER OF STANDARDS

Asst. Eng. of Roadway Standards

Engineer of Standards

Approved



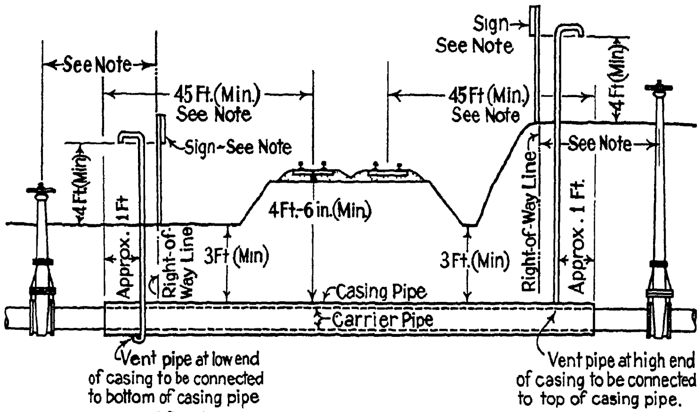
Size Of Shim			[illegible]
Width	Length	Thickness	
7"	12"	¼"	50
7"	12"	½"	25
7"	12"	¾"	20
7"	12"	1"	10
7"	12"	1¼"	10
7"	24"	1½"	5
7"	24"	1¾"	5
7"	24"	2"	5
7"	24"	2¼"	5

Appendix I

(13) SPECIFICATIONS FOR PIPE LINE CROSSINGS UNDER RAILWAY TRACKS

P. T. Simons, Chairman, Sub-Committee; J. B. Arter, C. W. Baldridge, H. B. Barry, J. N. Grim, E. H. Piper, L. S. Rose.

1. Pipe lines conveying oil, gas, gasoline or other inflammable substances, steam, or liquid at pressure under railway track and right-of-way shall be encased in a larger pipe installed as indicated in Fig. 1. Sizes of casing pipe to be used with various sizes of pipe lines are shown in Table 1.



NOTE: Valve at accessible location near (not more than 500 ft. from) railroad right-of-way line.
Casing to extend beyond limit of railroad right-of-way.
Sign with words **"PIPE LINE CROSSING"** to be placed, facing track, at each right-of-way line.

TABLE 1—Diameters in Inches for Line and Casing Pipe

Line	Casing	Line	Casing	Line	Casing	Line	Casing
1	2½	5	8	11	15	17	22
1½	3½	6	9	12	16	18	22
2	4	7	10	13	18	20	24
2½	5	8	11	14	18	21	26
3	5	9	12	15	20	22	26
4	7	10	14	16	20	24	28

2. Carrier line pipe inside of casing on railroad right-of-way shall be of good construction of steel, wrought iron, pure or alloyed iron and shall be either seamless or substantially welded pipe; with welded or approved coupling joints and the outside shall be thoroughly coated with an approved preservative. Pipe line shall be laid with slack (no tension) in the line near point of railway crossing.

3. Casing pipe may be of any of the kinds specified for carrier line pipe or of cast iron and shall have welded or coupling joints. Casing pipe and joints shall be capable of withstanding load of railroad's roadbed, track and traffic; also capable of withstanding test pressure of the pipe line.

4. Where casing pipe terminates below ground surface, the ends shall be sealed to the outside of the carrier pipe line with approved joints capable of withstanding work-

ing pressure of the pipe line. Each end of casing pipe shall be fitted with a vertical pipe vent having diameter of not less than 2 inches and carried to a height of not less than 4 feet above the ground surface. Casing pipe shall be installed on sloping grade line of at least .3 per cent. Vent pipe at low end of casing shall be connected with bottom of casing and vent at high end shall be connected with top of casing. Upper end of vent pipes shall be fitted with down-turned elbow pointing away from track and screened with brass or copper screening 20 meshes to the inch.

Where casing pipe terminates above ground surface, the ends may be left open provided drainage is afforded in such manner that leakage will be conducted away from railway tracks or structures.

5. The distance from base of rail to top of casing pipe at its closest point shall be not less than 4½ feet. Where pipe line is not directly beneath any track, the distance from surface of railway right-of-way and from bottom of ditches to the top of casing pipe shall be not less than 3 feet.

6. Casing pipe shall extend across railway right-of-way and at least 45 feet each side from the center line of nearest railway track measured at right angles thereto and shall be given an even bearing throughout its entire length.

7. Carrier pipe line shall be provided with suitable shutoff valves at conveniently accessible locations near railway right-of-way lines on both sides of track in order to prevent escape of material on right-of-way in case of failure in the pipe line between the valves.

8. Location:

Pipe lines shall be located to cross tracks at approximately right angles thereto and wherever practicable shall not be closer than 45 feet to any portion of any railway bridge, building or other important structure which might be injured by leakage from or failure of the pipe line.

Pipe lines, casing pipe and vent pipes shall be at least 4 feet from aerial electric wires and at least 8 feet from underground conduits carrying electric wires on railway right-of-way.

9. Crossings under railroad tracks of pipe lines carrying volatile and highly inflammable material such as gasoline and natural gas shall be located near the summit of the topography where the terrain slopes downward away from the railroad in at least two directions.

10. Plans for a proposed crossing shall be submitted to and be approved by the Chief Engineer of the railway before installation proceeds and the carrying out of the work on railway right-of-way including the supporting of track shall be subject to his direction and inspection.

REPORT OF COMMITTEE XII—RULES AND ORGANIZATION

E. H. Barnhart, *Chairman;*
J. P. Anderson,
F. W. Armistead,
M. M. Backus,
W. C. Barrett,
D. P. Beach,
L. D. Beatty,
Richard Brooke,
H. L. Browne,
C. J. Chase,
P. D. Coons,
J. L. Downs,
J. J. Davis,
H. W. Graham,
R. E. Warden, *Vice-Chairman;*
A. B. Griggs,
J. H. Guest,
R. C. Harris,
H. C. Hayes,
A. A. Jackson,
A. R. Jones,
B. R. Kulp,
W. C. Mack,
R. D. Martin,
S. F. Ryan,
C. B. Teller,
F. B. Wiegand,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual, collaborating with appropriate Committees (Appendices A and B).

The Committee offers for approval and printing in the Manual the subject matter outlined in Appendix A. Committee XVI—Economics of Railway Location reported in Bulletin 331, pages 232–234, information on proper size and character of Field Organizations for Railway Location and Construction, and since this material was recommended for approval and printing in the Manual, there being material already in the 1929 Manual (pages 789–792) bearing on this same subject, the Committee withdrew its recommendations and your Committee was instructed to collaborate with Committee XVI so that the additional material might be harmonized with that already in the Manual.

Appendix A gives the changes in the Manual necessary to reconcile the differences and this material has been approved by Committee XVI.

In order to harmonize the wording of the definitions of typical positions under Organization, pages 809–810 of 1929 Manual, with wording of definitions of other typical positions offered in Appendix F there is given in Appendix B for approval and printing in the Manual pages 809–810 revised definitions—which wording now conforms to that indicated in Appendix F.

(2) Rules for the guidance of employees of the Maintenance of Way Department, with special reference to:

(a) Maintenance of Bridges, collaborating with Committees VII—Wooden Bridges and Trestles, VIII—Masonry, and XV—Iron and Steel Structures (Appendics C and D).

(b) Maintenance of Structures other than Buildings, collaborating with Committees VI—Buildings, XIV—Yards and Terminals, and XXIII—Shops and Locomotive Terminals (Appendix E).

(c) Maintenance of telegraph and telephone lines and appurtenances, collaborating with Telegraph and Telephone Section, A. R. A.

(2-a) The Committee offers for approval and printing in the Manual Rules 1100 to 1112 inclusive as shown in Appendix C—Rules for Maintenance of Bridges—Steel Structures. These rules have the approval of Committee XV—Iron and Steel Structures.

The Committee offers as information seven rules as shown in Appendix D—Rules for Maintenance of Bridges—Masonry and Composite Structures. The Committee has

Bulletin 342, December, 1931.

not had opportunity to secure the approval of the collaborating committees, but will do so during the ensuing year.

(2-b) The Committee offers as information in Appendix E additional rules for terminal structures other than buildings.

(2-c). The Sub-Committee having in charge the preparation of rules for maintenance of telegraph and telephone lines and appurtenances has been in collaboration with a sub-committee of the Telegraph and Telephone Section A. R. A. and the two sub-committees have reached an agreement on the method of procedure. If this meets with the approval of the Telegraph and Telephone Section A. R. A., the sub-committees will work together and this Committee hopes to have some information to submit to the Association next year.

(3) Titles employed to designate positions of corresponding rank in maintenance of way service, subordinate to that of Division Engineer; recommend proper titles for positions now assigned to Assistant Engineers in departments other than Maintenance of Way (Appendices F and G).

The Committee offers in Appendix F for approval and printing in the Manual titles to designate positions of Assistant Engineer—and Foremen—in Maintenance of Way Department.

The titles shown in Appendix F were offered last year as information and printed on page 142 of the 1931 Proceedings.

The Committee offers as information the titles shown in Appendix G for positions below the rank of Foreman. These titles were selected from a summary of replies to questionnaires sent to thirty-three of the principal railways of the United States and Canada. A majority of these titles are more commonly used than equivalent titles of corresponding rank and some of them have been in general use by this Association in the past.

It is the sense of the Committee that these titles are proper to designate positions of corresponding rank in Maintenance of Way service and to promote uniformity in nomenclature.

Progress has been made by your Committee in endeavoring to suggest a proper title for the position of Assistant Engineer in departments other than Maintenance of Way, but the Committee is not in position to submit a report at this time. A questionnaire was sent to a number of the representative railways, and replies received to date contain some interesting data, which the Committee is now analyzing.

(4) Rules for fire prevention as applying to Maintenance of Way Department, collaborating with Railway Five Protection Association.

The Committee offers as information in Appendix H a number of rules for fire prevention as applying to the Maintenance of Way Department. These rules are formulated as duties of the several divisional supervisory officers and when approved for printing in the Manual will be inserted in the Manual for Rules for the Guidance of Employees of the Maintenance of Way Department in numerical order as indicated.

Your Committee has collaborated with the Railway Fire Protection Association and has received their tentative approval of same. However, before submitting these rules for approval and printing in the Manual they will again be submitted to that association.

Respectfully submitted,

The Committee on Rules and Organization,

E. H. Barnhart, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

P. D. Coons, Chairman, Sub-Committee

(1) MANUAL OF INSTRUCTIONS FOR THE GUIDANCE OF ENGINEERING FIELD PARTIES

(Pages 789–792)

Present Form	*Proposed Form*
(I) GENERAL	GENERAL
Purpose and Scope	Subject matter unchanged.
None.	LOCATION
(II) BEFORE GOING INTO THE FIELD	(I) BEFORE GOING INTO THE FIELD
First two paragraphs.	Unchanged.
None.	**Reconnaissance** Reconnaissance sufficient to determine the general route, and principal governing points should precede the organization of survey parties and attention is called to the use of the aeroplane and stadia surveys in this connection, especially in unmapped territory.
Personnel of Party The Chief of Party should have the right to select the members of the party whenever feasible; especially on extensive surveys, when he should satisfy himself that the men will be able to stand the work under the climatic and other conditions encountered. Local people should be employed as helpers whenever possible so that advantage may be taken of their knowledge of local conditions, and sometimes the sympathetic interest of the community may be enlisted by this practice.	**Personnel of Party** The personnel of field organizations varies greatly according to conditions as to (a) Character of country, flat or mountainous, prairie land, dense forests, or extensive swamps; (b) Distance from "civilization" or source of supply; (c) Presence (or absence) of the special conditions which have made some surveys particularly difficult, arduous and even dangerous. For purposes of analysis, the personnel should be divided into two classes—the technical and the non-technical men. The technical men include the leader or "chief-of-party," the instrument men, and all those who must have technical qualifications and training. The non-technical men include cooks, teamsters, axemen, and all those whose duties can be performed by untrained men, who should be recruited locally, whenever possible so that advantage may be taken of their knowledge of local conditions and sometimes the sympathetic interest of the community may be enlisted by this practice. The larger part of the variations in personnel apply to the non-technical men. The personnel list of these men will vary

according to circumstances, and the list may sometimes be increased or diminished as the survey progresses, if circumstances warrant it and new recruits are readily obtainable when desired.

Since the progress of the survey depends on having each man working to the proper limit of his capacity, so that the party as a whole is not delayed waiting for an overloaded man to do his work or cause him to slight his work in order to keep up with the party, much depends on a proper balance of the personnel. For example, a large party whose daily or hourly cost, in salaries and expenses, is very large, might be delayed by an insufficiency of axemen, the cost of the extra axemen being only a small part of the cost of the delay of the whole party. This general principle will explain the necessity of adding to the party some men who are frequently omitted from such lists with the mistaken idea of "economy". For example, a "recorder" who should attend the transitman, particularly on preliminary surveys and especially when the stadia method is used, will permit the transitman to devote his entire attention to his transit, avoid errors or inaccuracies due to a too hasty reading of angles, and the recorder will be able to produce more complete, legible and accurate notes for the use of the draftsman who plots the notes. One of the duties of the chief-of-party should be to watch the balance of the working force, and maintain the steady regular progress of the survey. A slight excess of cheap, nontechnical men is less expensive than delays of the whole party.

None.

Field Methods

(a) STADIA. Except in timbered country, the stadia method of obtaining the requisite topography, on which to base the "paper location," is often more rapid and efficient than the method of obtaining topography by cross-sections with a hand level. Some of the unpopularity of the stadia method is due to lack of familiarity with some of the refinements of the method (using stadia slide rule, etc.) by which the work is facilitated and made more rapid and accurate. Whenever a "first" and "second" preliminary survey is made (perhaps only for short difficult sections) the first survey may preferably be made by stadia. The stadia, however, is usually only applicable to continuously open country.

The personnel for stadia survey should be: chief-of-party, transitman, recorder, and two, three or four rodmen. When well organized and trained, four rodmen can be

kept literally on the run, the number of "shots" in a day's work will be correspondingly increased, the information obtained will be more complete and the progress of the party more rapid. A draftsman at the temporary field headquarters should each day completely plot the previous day's work. Levels should be controlled and checked by a regular level party and one or two axemen and other non-technical men as conditions require.

(b) PLANE TABLE. The plane table may be used as an adjunct of the stadia survey and also for taking topography on suitable terrain if the personnel is familiar with its use and climatic conditions are such that its use will not interfere with the general progress of the survey.

Size of Party

The size of the party should be adapted to the work to be done, i.e., a sufficient number of engineering assistants with ample training for their respective positions, and of intelligent helpers should be provided to handle the work expeditiously and economically.

Size of Party

The following is suggested for the make-up of maximum and minimum parties for location:

MAXIMUM LOCATING PARTY

1 Chief-of-Party
1 Office Draftsman
1 Estimator (optional)

Transit Party
1 Transitman
1 Levelman
2 Flagmen
2 Chainmen
2 Axemen or More*

Topography Party
1 Topographer
2 Rodmen

Land Line Party
1 Instrumentman
1 Flagman
1 Chainman
1 Axeman or More*

Conveyance and Subsistence
1 Cook
1 Flunkey

If Automobile Can be Used
1 Light Truck with Shallow Bed
1 Light Automobile

Where Teams Have to be Used
2 Two-Horse Teams and Wagons*
1 Saddle Horse
1 Complete Camp Outfit to accommodate number of men in party

* Number of axemen and teams vary with character of country and in all cases should be left to the judgment of the Chief-of-Party.

MINIMUM LOCATING PARTY

1 Chief-of-Party
1 Instrumentman
1 Rodman
2 Chainmen
2 Axemen or More*

Conveyance and Subsistence
2 Light Automobiles
Party stay at hotel or boarding house

* Size of parties governed by local conditions, ruggedness of country, length of line and time in which survey is to be completed.

The balance of the article on "Before Going into the Field" is unchanged.

(III) AFTER ARRIVING IN THE FIELD

(II). AFTER ARRIVING IN THE FIELD

The following is new material and will follow the subject matter now in the Manual appearing under the heading "After Arriving in the Field".

None.

CONSTRUCTION

On a large construction project, about every five (5) residences should have the following headquarters organization:

Assistant Construction Engineer
Office Engineer
Assistant Office Engineer
Clerk
Stenographer

In certain parts of the world a doctor and complete medical outfit may be attached to Headquarters and special provision may have to be made for distribution of supplies of all kinds.

Residencies will usually be about ten (10) miles in length, the personnel varying with the character of the work. (In some cases, the personnel may be the same on all residencies and the length of residency varied in accordance with the character of the work.)

For residencies ten (10) miles in length, the following is suggested:

Light Work
Resident Engineer
Instrumentman
2 Rodmen
1 Chainman
1 Axeman (stakeman)

Heavy Work (Including Tunnels and Heavy Bridges).
Resident Engineer
1 Office Engineer
3 to 4 Instrumentmen
3 to 4 Rodmen
3 Chainmen
3 Axemen (stakemen)

Necessary transportation should be provided; auto or horse for the Resident Engineer and light trucks or wagons for the rest of the party.

Cooks and cook outfits, if required.

Necessary inspectors for masonry, steel or timber bridges, tunnels, buildings, water supply, etc.

Appendix B

(1) REVISION OF MANUAL

P. D. Coons, Chairman, Sub-Committee

(1) ORGANIZATION

TITLES OF RANK OF DIVISION ENGINEER AND BELOW, TO DESIGNATE POSITIONS OF CORRESPONDING RANK IN MAINTENANCE OF WAY SERVICE

(Payer 809–810)

Present Form	*Proposed Form*
Division Engineer is title of chief maintenance officer on Division.	Division Engineer — Chief maintenance officer on Division.
Supervisor of Bridges and Buildings is the title assigned to the supervisory officer responsible for maintenance of bridges, buildings and structures.	Supervisor of Bridges & Buildings—Supervisory officer responsible for maintenance of bridges, buildings and structures.
Supervisor of Water Service is the title assigned to the supervisory officer responsible for maintenance of water service.	Supervisor of Water Service—Supervisory officer responsible for maintenance of water service.
Supervisor of Signals is the title assigned to the supervisory officer responsible for maintenance of signals.	Supervisor of Signals—Supervisory officer responsible for maintenance of signals.
Supervisor of Telegraph and Telephone is the title assigned to the supervisory officer responsible for maintenance of telegraph and telephone.	Supervisor of Telegraph and Telephone —Supervisory officer responsible for maintenance of telegraph and telephone.
Supervisor of Track is the title assigned to the supervisory officer responsible for maintenance of track.	Supervisor of Track—Supervisory officer responsible for maintenance of track.
Supervisor of Work Equipment is the title assigned to the supervisory officer responsible for the maintenance of work equipment.	Supervisor of Work Equipment—Supervisory officer responsible for maintenance of work equipment.

Appendix C

(2-A) RULES FOR MAINTENANCE OF BRIDGES—STEEL STRUCTURES

A. B. Griggs, Chairman, Sub-Committee

1100. Nuts on floorbeam hangers must be brought to a bearing; expansion bearings of all metal bridges must be kept clean, properly lubricated and free to expand or contract; rivets attaching stringers to floorbeams and beams to posts must be kept tight.

1101. When adjustable lateral or center rods are found to be loose or damaged, prompt report must be made to Supervisor of Bridges and Buildings.

1102. Rigging, staging and scaffolding must be substantially placed and it must be known that same is safe before permitting its use, when within standard clearance, flag protection must be provided in accordance with rules and Superintendent notified.

1103. Space between steel and backwalls must be kept clean.

1104. Worn or distorted base or cap plates should be reinforced or replaced.

1105. Anchor bolts must be kept in place and nuts tight.

1106. Cracked or broken castings must be replaced.

1107. Lattice bars or batten plates that are broken, bent or that have a reduced section must be replaced.

1108. Flanges that are broken, worn or distorted must be replaced.

1109. Alinement of compression members must be checked and if found to be out of line reported to Supervisor of Bridges and Buildings.

1110. Rivets having broken heads or that are loose must be replaced.

1111. The ballast must be kept away from the steel on ballast deck bridges. Where there is a concrete floor a waterproof joint must be maintained between the concrete and the girder web.

1112. On open deck bridges proper clearance must be maintained between base of rail and top of floorbeams.

Appendix D

RULES FOR THE MAINTENANCE OF BRIDGES—MASONRY

A. B. Griggs, Chairman, Sub-Committee

1150. Drains or "Weep holes" in abutments, retaining walls and arches must be kept open to insure full operation of the drainage system.

1151. Inadequate drainage behind abutments, retaining walls, above flat slabs and arches may be remedied by proper placing of drain tile or pipe.

1152. Bridge seats that have become weakened through disintegration or overload must be replaced with approved quality concrete.

1153. Areas of masonry that have become disintegrated to an extent dangering the strength of the structure must be repaired by patches of sufficient thickness and thoroughly cured observing the following general principles:

(a) Loose material should be removed to expose sound concrete or stone and rust and scale must be removed from exposed reinforcement.

(b) A shoulder preferably undercut should be formed in the sound concrete or stone to avoid a feather edge patch.

(c) The surface must be cleaned, roughened and just before applying the patch saturated with water.

(d) First coat of patching material must be under pressure so that there will be no air or dust film between the patch and the old surface.

1154. Individual stones in masonry structures showing marked disintegration must be removed and replaced with stiff concrete rammed into place and well-cured to prevent shrinkage.

1155. Stone or concrete structure showing disintegration over a large part of the surface or which is otherwise structurally weak must be rebuilt or be protected by an encasement of concrete of approved mixture and of sufficient thickness. The encasement must be properly reinforced and doweled to the old masonry and well-cured to prevent shrinkage.

1156. Joints in stone masonry must be kept well-pointed. Before pointing, all loose material must be removed and the joints well-moistened.

Appendix E

(2-B) RULES FOR MAINTENANCE OF OTHER TERMINAL STRUCTURES

B. R. Kulp, Chairman, Sub-Committee

Turntables

1. Turntables must be given a close inspection at regular intervals.
2. Careful maintenance must be given at all times by each Department assigned to the various units. The center pier must be kept level, firm and unyielding.
3. Circle rails must be kept in correct surface and alinement.
4. Track rails must be in good surface, anchored against end movement and properly supported at the ends of tables.

Oil Houses

1. Repairs must not be made with open flame lights, and in no case until investigation has been made to determine that there do not exist any oil or gas fumes.

Appendix F

(3) TITLES EMPLOYED TO DESIGNATE POSITIONS OF CORRESPONDING RANK IN MAINTENANCE OF WAY SERVICE, SUBORDINATE TO THAT OF DIVISION ENGINEER. RECOMMEND PROPER TITLES FOR POSITIONS NOW ASSIGNED TO ASSISTANT ENGINEERS IN DEPARTMENTS OTHER THAN MAINTENANCE OF WAY

Richard Brooke, Chairman, Sub-Committee

ASSISTANT ENGINEERS—MAINTENANCE OF WAY DEPARTMENT

(1) Assistant Division Engineer.—Engineer who reports to the Division Engineer, supervises general maintenance work and acts for the Division Engineer in his absence.

(2) Assistant Engineer, Maintenance.—Engineer who reports to the Division Engineer, is responsible for the preparation of plans and estimates and supervises field and office engineering work.

FOREMAN—MAINTENANCE OF WAY DEPARTMENT

(1) General Foreman.—Supervisory officer responsible for the maintenance and construction of track on an assigned territory or assigned project.

(2) Section Foreman.—Foreman responsible for the maintenance of track, roadbed and right-of-way on a designated territory.

(3) Extra Gang Foreman.—Foreman of a floating gang engaged in laying rail, applying ballast or other track or roadway work, usually requiring a larger organization than a section gang.

(4) Work Train Foreman.—Foreman in general charge of a work train and a gang handling material and doing other work performed with a work train.

(5) Welder Foreman.—Foreman in charge of building up rail ends, frogs and switches in and along the track.

(6) General Foreman, Bridges and Buildings.—Supervisory officer responsible for the maintenance and construction of bridges and buildings on an assigned territory.

(7) Bridge and Building Foreman.—Foreman in charge of maintenance and construction of bridges and buildings.

(8) Mason Foreman.—Foreman in charge of maintenance and construction of masonry.

(9) Painter Foreman.—Foreman in charge of the painting of bridges and buildings.

(10) Plumber Foreman.—Foreman in charge of maintenance and construction of plumbing.

(11) Tinner Foreman.—Foreman in charge of sheet metal work.

(12) Fence Foreman.—Foreman in charge of maintenance and construction of fences.

(13) Water Service Foreman.—Foreman in charge of maintenance and construction of water service facilities.

(14) Signal Foreman.—Foreman in charge of maintenance and construction of signals and interlockers.

Appendix G

(3) POSITIONS BELOW THE RANK OF FOREMAN—MAINTENANCE OF WAY DEPARTMENT

Richard Brooke, Chairman, Sub-Committee

Assistant Bridge and Building Foreman
Assistant Extra Gang Foreman
Assistant Mason Foreman
Assistant Painter Foreman
Assistant Section Foreman
Assistant Signal Foreman
Assistant Water Service Foreman
Assistant Signal Maintainer
Assistant Signalman
Assistant Work Equipment Operator
Bridge Inspector
Bridge Watchman
Carpenter
Carpenter Helper
Crossing Watchman
Extra Gang Laborer
Lampman
Leading Signal Maintainer
Leading Signalman
Mason
Painter
Plumber
Pumper
Section Laborer
Signal Helper
Signal Maintainer
Signalman
Track Machine Operator
Track Walker
Track Watchman
Tunnel Watchman
Water Serviceman
Welder
Work Equipment Operator

Appendix H

(4) RULES FOR FIRE PREVENTION AS APPLYING TO MAINTENANCE OF WAY DEPARTMENT

W C. Mack, Chairman, Sub-Committee

Co-operation

All duties pertaining to fire prevention measures and fire protection equipment shall be exercised by the officials named herein, under full co-operation with the Superintendent of Fire Prevention, local Chiefs of Fire Brigades and with such other officials as may be specifically responsible for fire prevention matters.

Division Engineers

302. They are responsible for fire prevention conditions on their respective divisions. They will see that terminals are laid out and buildings designed with proper attention to fire prevention. They must know that their Supervisors are properly instructed in fire prevention rules, alert in decreasing fire hazards and exacting in the maintenance and operation of fire fighting apparatus.

Supervisors of Track

316. They must give particular attention to fire hazards from adjoining property and from structures erected on railway property by lessees.
317. They must see that those under their supervision do not obstruct fire roads, fire hydrants and hose houses.
318. They must see that no lumber, ties, piling or other inflammable materials are piled within fifty (50) feet of any important building and that automobiles or trucks are not parked in a manner which constitutes a fire hazard.
319. They must know that all their foremen understand and rigidly observe all fire prevention rules.

Supervisors of Bridges and Buildings

374. They must give particular attention to fire hazards where the risk is extreme, such as oil houses, paint shops, wood coal chutes, cotton platforms, etc. Plans must be made to confine any fire in the place of origin.
375. They must make proper reports to superiors so that no unguarded fire hazards are allowed to develop due to the manner of operation of any shop or office.
376. They must see that those under their supervision do not obstruct fire escapes and exit passages thereto, fire doors, hose reels, fire hydrants, fire roads, and hose houses.
377. They must see that all those under their supervision are familiar with the location and use of the nearest fire alarms on the property.
378. They must see that all sprinkler systems are maintained in positive working condition and that all fire fighting apparatus is in good working order and ready for instant use by assigned employees.
379. They must arrange for the proper co-operation of all municipal fire departments.

379–a. They must make recommmendations for necessary fire walls, doors, shutters, etc., and for the removal of any fire hazards.

379–b. They must know that all their foremen understand and rigidly observe all fire prevention rules.

Supervisors of Water Service

423. They must know that fire pumps and fire lines are in good working condition and able to deliver sufficient volume of water to quench any fire on the property. They must see that fire hydrants and hose are always ready for instant use.
424. They must see that, where possible, proper connections are made to all municipal fire mains.
425. They must know that all their foremen understand and rigidly observe all fire prevention rules.

Supervisors of Telegraph and Telephones

609. They are responsible for the proper installation and maintenance of all electrical fire alarm systems and must see that all fire alarms are in working order.
610. They must see that the proper connections are made to all municipal fire alarm systems.
611. They must see that all wires are properly installed and equipped with approved protective devices.
612. They must see that all defects which tend to increase risk of, or cause fire, are given prompt attention.
613. They must know that all their foremen understand and rigidly observe all fire prevention rules.

REPORT OF COMMITTEE II—BALLAST

A. P. Crosley, *Chairman;*
Porter Allen,
D. C. Barrett,
G. J. Bell,
H. B. Christianson,
W. E. Colladay,
C. J. Coon,
R. C. Dunlay,
M. I. Dunn,
H. F. Fifield,
W. L. Foster,
A. T. Goldbeck,
C. G. Grove,
Daniel Hubbard,
A. A. Johnson,
W. C. Kegler,
A. D. Kennedy,
O. N. Lackey,
C. E. Dare, *Vice-Chairman;*
S. H. Osborne,
W. W. Patchell,
J. M. Podmore,
H. M. Righter,
P. T. Robinson,
W. A. Roderick,
E. I. Rogers,
S. A. Seely,
W. J. Shaw, Jr.
J. A. Snyder,
C. B. Stanton,
J. W. Stone,
H. E. Tyrrell,
Stanton Walker,
A. H. Woerner,
A. O. Wolff,
C. H. Zentmyer,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report on the following subjects:

(1) Revision of Manual.

(2) Specifications for prepared gravel ballast, including best method of testing for hardness, abrasion, and resistance to weathering (Appendix A).

(3) Specifications for stone ballast, including best method of testing for hardness, abrasion and resistance to weathering (Appendix B).

(4) Shrinkage of ballast (Appendix C).

(5) Comparative costs of maintaining track on various kinds of ballast (Appendix D).

(6) Determine proper depth and kind of sub-ballast (Appendix E).

Action Recommended

(1) The Committee has given special attention during the year to the ballast sections as now appearing in the Manual. Data has been secured but is not in form to warrant any recommendations at this time.

(2) That Appendix A be accepted as information.

(3) That the recommendations of the Sub-Committee, Appendix B, dealing with changes in the specifications for stone ballast, be approved.

(4) That the report as appearing in Appendix C be accepted as information and the subject discontinued.

(5) That the report as appearing in Appendix D be accepted as information and the subject continued.

(6) That the revision as recommended in Appendix E be approved and the subject continued.

Respectfully submitted,

The Committee on Ballast,
A. P. Crosley, *Chairman.*

Bulletin, 342, December, 1931.

Appendix A

(2) SPECIFICATIONS FOR PREPARED GRAVEL BALLAST, INCLUDING BEST METHOD OF TESTING FOR HARDNESS, ABRASION AND RESISTANCE TO WEATHERING

C. B. Stanton, Chairman, Sub-Committee; Porter Allen, H. F. Fifield, W. L. Foster, O. N. Lackey, W. A. Roderick, S. A. Seely, W. J. Shaw, Jr., Stanton Walker.

The principal work of the Sub-Committee on Prepared Gravel Ballast has consisted of the collection of information to assist in the formulation of specification clauses to cover such factors as resistance to abrasion and resistance to the action of the weather. A questionnaire was sent out to the railroads to determine the extent to which the present specifications are being used, also to serve as a guide to the Committee in the further study of the specifications. Many replies have been received, but the Committee has been unable to get these in shape for presentation.

In the study of the first problem, the revision of the present specification to include clauses covering abrasion and durability, the Committee has had conducted detailed tests to determine the physical characteristics of several samples of gravel ballast. This work has been carried out by W. L. Foster of the Iowa State College, Ames, Iowa, and Stanton Walker of the National Sand and Gravel Association, Washington, D. C., members of the Committee. The samples tested by Professor Foster were, for the most part, submitted by the railroads; those tested by the National Sand and Gravel Association, in most cases, were submitted by producers of gravel ballast, although a few were submitted by railroads.

To supplement the results of the laboratory investigations, a request was sent to railway engineers familiar with the specific gravels which had been tested in the laboratory, asking them for their experience with the gravel ballast under discussion and also that they give all of the information which they might feel would be pertinent to the question. The Committee suggested the following questions as a guide for this discussion:

1. Strength in track support or resistance to breaking down under traffic and tamping.
2. Stability or resistance to displacement in the roadbed.
3. Durability or resistance to disintegration due to weathering.
4. Drainage properties.
5. Effect of grading of sizes in improving stability, drainage and retarding fouling. If screen analyses are available please furnish the same.
6. Maintenance: Chief cause for need of maintenance inherent to ballast.
7. Depth of ballast used.
8. Weight of rail in service.
9. Average number of tonnage of trains carried by this ballast per day, both passenger and freight.

Tests on several of the samples submitted to the National Sand and Gravel Association have been reported previously to the Association. The results are published in the November, 1929, Bulletin, and on pages 764 and 765 of Vol. 31 of the Proceedings. The data include descriptions of the samples, sieve analyses, percentage of crushed particles, weight per cu. ft., specific gravity, absorption, resistance to abrasion, and resistance to crushing of 16 samples of ballast. Since that report, 5 additional samples have been tested in the same manner and all samples, 21 in number, have been subjected to an accelerated soundness test using sodium sulfate.

Tables 1, 2 and 3 as given below are similar to Tables 1, 2 and 3 appearing on pages 764 and 765 of Vol. 31 of the Proceedings and cover five additional samples which have been received for test subsequent to the report on the sixteen original samples. Table 4 covers the accelerated soundness test using sodium sulfate on the twenty-one samples.

Note.—Tests described in Tables 1, 2, 3 and 4 carried out in Research Laboratory of the National Sand and Gravel Association.

TABLE 1. DESCRIPTION OF SAMPLES OF GRAVEL BALLAST

Lot No.	*Source*	*Principal Mineral Constituent*
368	Northern Illinois	Rounded limestone and sandstone.
371	Western Ohio	Rounded limestone and dolomite.
377	Ontario Province, Can.	Rounded limestone, dolomite and sandstone.
383	Southeastern Mich.	Rounded sandstone, quartzite, limestone and igneous rocks.
384	Southeastern Mo.	Angular chert.

TABLE 2. MECHANICAL ANALYSES OF SAMPLES OF GRAVEL BALLAST

Lot No.	*Source*	*Amounts coarser than each sieve, inches, per cent by weight* No. 4	⅜	¾	1	1½	2	*Per cent Crushed Particles*	*Weight per cu. ft.* Loose	Rodded
368	Illinois	78	65	28	14	6	0	25	119.4	125.5
371	Ohio	83	62	24	9	0	0	57	104.3	110.2
377	Canada	34	24	13	8	3	0	24	114.8	120.4
383	Michigan	91	72	40	24	7	0	43	109.5	115.9
384	Missouri	80	60	32	14	3	0	85*	98.9	105.9

* Having sharp edges apparently freshly broken.

TABLE 3. PHYSICAL TESTS OF SAMPLES OF GRAVEL BALLAST

Lot No.	*Source*	*Apparent Specific Gravity*	*Absorption, per cent by weight*	*Deval Abrasion Test, per cent wear by weight*	*Crushing Test* — *Reduction in Fineness Modulus**	*Crushing Test* — *Reduction in Voids Per cent†*
368	Illinois	2.58	2.47	6.8	1.30	40.5
371	Ohio	2.60	1.83	5.9	1.21	41.4
377	Canada	2.67	1.26	10.4‡	1.25	43.7
383	Michigan	2.68	0.74	5.4	0.83	26.7
384	Missouri	2.47	1.80	5.4	1.13	31.0

* Difference in fineness modulus before and after test.
† Difference in voids before and after test expressed as percentage of voids before test.
‡ Abrasion sample was of finer grading than that of other samples in the table. Value obtained by proportion to values obtained on comparison sample which was graded similarly and was also tested the same as the other samples reported.

Table 4. Accelerated Soundness Tests of Gravel Ballast

Test consists of soaking 50 pieces of gravel representative of the average, in a saturated solution of sodium sulphate at 70 deg. F. for 19 hours, drying in an oven heated to 212 deg. F. for 4 hours and reimmersing in sodium sulfate after 1 hour of cooling. The condition of every gravel particle is noted after each alternation.

See notes at end of table for further identification of affected particles.

Condition of Particles After Each Alternation of Sodium Sulfate Treatment

Lot	1			2			3			4			5			6			7		
No.	OK	Ds	St	OK	Ds	St	OK	Ds	St	OK	Ds	St	OK	Ds	St	OK	Ds	St	OK	Ds	St
67	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0
68	50	0	0	50	0	0	49	0	1	48	0	2	48	0	2	48	0	2	48	0	2
70	50	0	0	50	0	0	49	0	1	48	0	2	48	0	2	48	0	2	48	0	2
71	48	2	0	48	2	0	45	3	2	41	4	5	40	5	5	40	5	5	39	5	6
74	50	0	0	50	0	0	50	0	0	48	0	2	48	0	2	48	0	2	48	0	2
77	50	0	0	50	0	0	50	0	0	50	0	0	46	0	4	46	0	4	44	0	6
78	50	0	0	50	0	0	50	0	0	50	0	0	49	0	1	49	0	1	49	0	1
80	50	0	0	50	0	0	50	0	0	49	0	1	49	0	1	49	0	1	48	0	2
81	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0	50	0	0
82	49	0	1	49	0	1	48	0	2	47	0	3	46	0	4	45	0	5	45	0	5
98	50	0	0	50	0	0	49	0	1	48	1	1	46	3	1	46	3	1	46	3	1
108	50	0	0	48	2	0	48	2	0	48	2	0	48	2	0	47	3	0	47	3	0
110	49	1	0	49	1	0	45	5	0	40	6	4	38	6	6	37	7	6	37	7	6
111	50	0	0	50	0	0	49	1	0	46	2	2	46	2	2	46	2	2	46	2	2
112	50	0	0	50	0	0	48	0	2	48	0	2	47	1	2	47	1	2	47	1	2
368	50	0	0	50	0	0	46	4	0	42	7	1	37	12	1	37	12	1	32	17	1
371	50	0	0	49	1	0	49	1	0	48	1	1	48	1	1	48	1	1	48	1	1
377	50	0	0	49	1	0	47	3	0	46	4	0	46	4	0	43	4	3	40	4	6
383	50	0	0	50	0	0	50	0	0	47	0	3	43	3	4	43	3	4	42	4	4
384	50	0	0	50	0	0	50	0	0	48	0	2	47	0	3	47	0	3	42	3	5

OK = sound Ds = disintegrated St = split

Note.—Affected particles were identified roughly for mineral composition as follows:

Lot 68—2 pieces of argillaceous limestone split.
Lot 70—2 pieces of argillaceous limestone badly split.
Lot 71—5 pieces of argillaceous limestone disintegrated, and 6 pieces of argillaceous limestone split (3 badly).
Lot 74—1 piece of shale and 1 piece of limestone split.
Lot 77—6 pieces of limestone split.
Lot 78—1 piece of quartzite split.
Lot 80—2 pieces of limestone split along bedding planes.
Lot 82—5 pieces of limestone split (1 dolomitic, 1 siliceous, and 3 argillaceous).
Lot 98—1 piece limestone split, 3 pieces of shale disintegrated.
Lot 108—2 pieces of shale and 1 piece of schist disintegrated.
Lot 110—2 pieces of shale, 2 pieces of argillaceous limestone, and 2 pieces of dolomitic limestone split; 2 pieces of shale, 3 pieces of argillaceous limestone, 1 piece of sandstone, and 1 piece of dolomitic limestone disintegrated.
Lot 111—2 pieces of argillaceous limestone split, 1 piece of argillaceous limestone, and 1 piece of serpentine disintegrated.
Lot 112—2 pieces of argillaceous limestone split, 1 piece of argillaceous limestone disintegrated.
Lot 368—10 pieces of argillaceous limestone, 5 pieces of dolomitic limestone, and 2 pieces of shale disintegrated; 1 piece of limestone split.
Lot 371—1 piece of shale disintegrated and 1 piece of limestone split.
Lot 377—1 piece of argillaceous limestone and 3 pieces of shale disintegrated; 2 pieces of dolomite and 4 pieces of limestone split.
Lot 383—3 pieces of sandstone and 1 piece of limestone split; 3 pieces of limestone and 1 piece of sandstone disintegrated.
Lot 384—6 pieces of chert split; 6 other pieces slightly chipped.

The results of certain of the tests carried out by Professor Foster have been presented to the Committee, but they have not as yet been summarized in such a manner as to permit of including in this report.

The questionnaire, designed to furnish information supplementing the laboratory tests, referred only to the samples tested by the National Sand and Gravel Association. The replies to it are very valuable and represent considerable thought on the part of those reporting. The Committee desires to give these replies detailed study in an attempt to correlate field life with the laboratory tests. The replies have been summarized in tabular form and considered by the Committee, but sufficient opportunity has not been had to study them in sufficient detail to permit drawing conclusions for specification limits or of including the summary in this report.

The Committee regrets that it must ask for further time before making definite recommendations for the clauses covering factors not included in the present specification. It feels, however, that the A.R.E.A. would rather wait for well-considered recommendations than to receive at this time a specification which further study might show to be totally inadequate. Nevertheless, it should be of interest to outline in a general way the nature of the additional clauses which the Committee feels should be added. The Committee will welcome criticism and suggestions on these clauses.

The present specification places no limitations on impurities other than dust, dirt, or loam. The Committee expects to recommend, at a later date, a substitution for the present Section 3, which will read somewhat as follows:

"DELETERIOUS SUBSTANCES.—Prepared gravel ballast, when tested as described in Sections ...., shall contain deleterious substances not in excess of the following values:

	Per cent by Weight
Dust, dirt or loam	½
Coal	1
Clay lumps	½
Other local deleterious substances	.."

The present specification contains no limitations on the hardness or resistance to abrasion of the ballast. The Committee is prepared to make recommendations concerning a method of test to cover these factors, but it does not desire to recommend specification limits until after it has had a better opportunity to study the results of the questionnaire relating to the service records of the ballast on which laboratory tests have been made. The Tentative Method of Test for Abrasion of Gravel of the American Society for Testing Materials (Serial Designation D 289-28T) would seem to offer a suitable method of test for determining the hardness and resistance to abrasion of gravel ballast. This test method consists of running a sample in a Deval abrasion testing machine with cast iron balls added as an abrasive charge. It gives, therefore, a combination of abrasion and impact and should furnish considerable information concerning the ability of the ballast to withstand breaking up under the action of placing and the movement of traffic. In view of the specifications for grading of prepared gravel ballast, it seems desirable to restrict the test to Grading "B" as outlined in that test method. It is expected that a study of the results of the questionnaire in connection with the laboratory tests will furnish information on which specification limits for this test method may be recommended.

It is important that gravel ballast consist of durable particles which will resist the disintegrating influences of the weather. The present specification contains no clause covering this factor. While entirely satisfactory methods of test for durability of aggregates have not been developed, the Committee expects to recommend the accept-

ance of the Tentative Method of Test for Soundness of Coarse Aggregate by Use of Sodium Sulfate of the American Society for Testing Materials (Serial Designation C 89-31T) for inclusion in the specification for prepared gravel ballast until such time as a better method is developed. The tests of soundness by use of sodium sulfate carried out by the Committee were made prior to the development of the A.S.T.M. method. The procedure followed, therefore, was not identical with the recommended procedure, although it is near enough the same so that the data which the Committee has collected (see Table 4 of this report), when considered in connection with the results of the questionnaire, will be of considerable assistance in determining what specification limit on disintegration should be adopted.

Appendix B

(3) SPECIFICATIONS FOR STONE BALLAST, INCLUDING BEST METHOD OF TESTING FOR HARDNESS, ABRASION AND RESISTANCE TO WEATHERING

A. A. Johnson, Chairman, Sub-Committee; D. C. Barrett, C. J. Coon, R. C. Dunlay, W. L. Foster, A. T. Goldbeck, W. W. Patchell, H. M. Righter, A. O. Wolff.

At the 1931 convention of the A.R.E.A. your Committee presented a revised and rearranged set of specifications for stone ballast and asked for the adoption of same. The A.R.E.A. approved the specifications. In presenting these specifications, the Committee called attention to the fact that the cementing value as contained in the specifications was incorrect and asked that no value be shown. The reason for this was due to the fact that by laboratory tests, it had been shown that this value was incorrect. The cementing value had been copied from the 1921 Manual.

Since the adoption of the revised specifications, the Committee has given this matter considerable study and feels that it is of such little importance that the sections pertaining to the cementing value should be dropped entirely. Section 24 of the specification outlines in detail the method to be used in determining the cementing value, and reads as follows:

One and one-tenth lb. (one-half kg.) of stone which can be crushed to pea size, shall be placed (dry) in a ball mill which contains two steel shot weighing 20 lb. (9.07 kg.) each, given 5000 revolutions at the rate of thirty (30) revolutions per minute, and the dough resulting from a mixture of the dust screened through a 100-mesh sieve, and water, placed in an air tight vessel for three (3) hours and then rekneaded shall be made into six cylindrical briquettes, 0.98 in. (25 m.m.) in diameter and 0.98 in. (25 m.m.) in height formed under a pressure of 1877.5 lb. per sq. in. (132 per square centimeter) after which they shall be allowed to dry 20 hours in air, four hours in a hot air bath of 212 deg. Fahr. (100 deg. Cent.) and then cooled for twenty minutes in a dessicator, and immediately tested in a machine for ascertaining the crushing strength in pounds per sq. in. which is the measure of the cementing value of the rock. The average of five (5) determinations should be taken.

Section 6 of the specification reads as follows:

"CEMENTING VALUE.—The cementing value shall not exceed .... pounds."

The primary reason in suggesting that the cementing value be dropped is that although hard, tough rocks, such as trap, may have the same cementing value as some of the softer rocks, such as the limestones, in practice the amount of dust formed through abrasion of the hard, tough rock may be almost negligible, whereas there may be a considerable amount formed from the softer rocks. Consequently, the cementing

action of the dust may be of no consequence in one case simply because there has been no appreciable amount of dust formed. It is clearly evident, therefore, that the first consideration in selecting a stone for ballast should be the question of soundness and toughness. With these factors given due consideration, so far as availability of supply will permit, the cementing value is of little consequence and cannot be prevented or controlled.

The Committee asks that Section 9 of the specifications covering Selection of Samples be modified. Present section reads as follows: "Each stratum of a quarry shall be tested separately and not averaged with any other stratum."

The proposed section to read as follows: "Each stratum or portion of the quarry containing a variation in quality of stone, shall be tested separately and not averaged with any other stratum or portion of the quarry."

The reasons for the above change are quite obvious and are more restrictive. The change will also assist in better controlling the output. As sometimes occurs, variations will be found in the same quarry and it is essential that these various strata be tested to determine their suitability for ballast purposes.

The Committee also feels that Section 10, Averaging, should be modified slightly. At present the number of tests required is given in tabular form and calls for five. It is felt that this can be simplified by changing the tabular form to a sentence. At the same time it is felt that instead of using the average of five tests that equally satisfactory results will be obtained by averaging three tests. The revised section would read as follows:

"For obtaining the values for physical tests, the average results from three samples representing a given stratum or portion of the quarry shall be taken."

Considerable work of a very interesting nature dealing with stability of ballast as affected by gradation and sizes has been in progress in the laboratory. The Committee feels that some exceedingly valuable information will be obtained from these experiments, but they have not been carried sufficiently far to warrant making a report at this time.

Recommendations

The Committee recommends that the following changes be made in the specifications:

That Sections 6 and 24 dealing with Cementing Value be removed; that Section 9 dealing with Selection of Sample be modified; and that Section 10 dealing with Averaging of Samples, be modified.

Appendix C

(4) SHRINKAGE OF BALLAST

W. E. Colladay, Chairman, Sub-Committee; G. J. Bell, W. C. Kegler, S. H. Osborne, J. M. Podmore, P. T. Robinson, J. W. Stone, A. H. Woerner.

This subject has been before the Committee for a number of years and has been studied and reports submitted at various times. At the March, 1924, convention the Ballast Committee reported to the Association certain recommendations for adoption and insertion in the Manual, as shown on page 113 of the 1929 Manual.

This section reads as follows: "Allow for shrinkage between measurements in the car and quantity required to bring track originally to standard section for both top and sub-ballast, from 8 per cent to 20 per cent."

At the convention of March, 1927, the Committee again reported on this subject advising that a questionnaire had been sent to the railroads to determine the extent to which the above information was being used. No additional information was obtained nor was any of the information in conflict with the data in the Manual.

The Committee asked that the subject be discontinued. However, on the floor of the convention considerable discussion took place on this subject, due in large part to the fact that it was generally felt that additional information should be secured if possible. As the Committee interpreted the original assignment, the shrinkage was between the measurement in the car and the quantity necessary to bring the track to the original section. Additional shrinkage takes place after traffic has been turned upon such a track and it was felt that this additional shrinkage should be determined. The question was, therefore, reassigned for further investigation.

The Committee interpreted the new assignment to be to determine the amount of shrinkage of ballast by comparing the yardage paid for at the point of origin with the yardage of the same material tamped and compacted in track under traffic, and was not to be confused with the shrinkage which occurs between the point of origin and the point of application. With this in mind, the Committee attempted to conceive ways in which such information might be obtained. Testimony presented before the Interstate Commerce Commission on this subject was reviewed and it appeared that the information which had been collected by the railroads was, for certain reasons, deemed inadequate.

In order to clear up somewhat just what is meant by shrinkage of ballast and determination of this, the Committee quotes from testimony presented before the Interstate Commerce Commission:

"By the shrinkage of ballast is meant the decrease in volume of the ballast as loaded at the pit and measured in cubic yards compared with the number of cubic yards measured in track after the ballast has been placed and seasoned. In the case of the measurement at the pit, ballast is dumped loosely into the car and paid for by the railroad in the yardage thus measured, whereas the identically same ballast when placed in the track and tamped and pounded down and compressed by passage of trains is materially reduced in cubical contents.

"From statements made and questions asked in regard to this subject, there seems to be a lack of familiarity with the actual conditions that take place in digging, preparing and loading ballast at the pit, together with the haulage, dumping and placing of ballast in the track, and a brief description will undoubtedly clear up some of these misunderstandings.

"Stone ballast is usually quarried in stone quarries and crushed to a proper size for use as ballast at the pit. After passing through the crusher, it is usually dumped into bins and held until it can be dumped into cars.

"Pit run gravel ballast is usually dug directly from the pit by a steam shovel and dumped loosely into ballast cars.

"Washed gravel ballast is dug either from pit or stream bed and then passed through the washer. The dirt and clay is removed and sometimes a certain proportion of the sand is removed, leaving the gravel and a proper proportion of sand in the prepared ballast. This in turn is usually dumped into a large bin and held until it can be dumped into the ballast cars.

"Other forms of ballast are handled in different ways, according to the kind of ballast, but in practically all cases the yardage of ballast for which the railroad pays is measured as a loosely dumped material, as it is first dumped into the car, and before it has even been solidified by the jolting of the car in switching and delivery to point of use.

"The measurement of the ballast at the pit is usually done by dumping the ballast loosely into the car and then leveling off the top of the ballast so that it can be accurately measured. Engineers are then assigned to the work of carefully measuring the yardage in a certain number of test cars, and after determining the yardage in each car accurately the car is moved to the track scale and the contents carefully weighed. By this method, the weight of a yard of ballast at that particular pit, dumped loosely into the car, is determined.

"The determination of the weight of a yard of ballast at the particular pit is generally based on the measurement of ten or more cars—sometimes fifty or a hundred, depending on local conditions. After this weight is determined with sufficient accuracy to satisfy the railroad company and the contractor, thereafter the ballast is generally paid for by weight, and this weight means the weight of a yard of ballast loosely dumped in the car.

"The cars are then moved to the point where the ballast is to be used and the ballast dumped onto the track. Considerable settlement and shrinkage of the ballast takes place in hauling the ballast from the pit in the car to point of use, but this is counterbalanced by the loosening of the ballast when it is dumped onto the track. The ballast, therefore, is delivered at the point of use in a very loose and expanded condition.

"As soon as it is dumped on the track, track gangs jack up the track and tamp the ballast under the ties. This tamping is done either with pick or shovel or tamping bar, depending on the method used by the railroad.

"After the track is sufficiently surfaced to permit the passage of trains, the trains pound down the ballast anywhere from an inch to two inches, depending upon the character of the ballast and the height of the 'lift' which the track has been given.

"From then on until the track is thoroughly seasoned, the ballast is tamped and retamped, the track is lined and relined, until the surface and line are sufficiently perfected for the character of traffic to be handled. After this the open spaces between the ties and the shoulder of the ballast are filled in with ballast.

"All this process of tamping, together with the pounding down of the ballast by the trains and the jar of trains in passing, forces and compacts this ballast into a much smaller space than when measured as it is loosely dumped into cars at the pit. That is to say, the identical yard of ballast as measured in the track by the Bureau of Valuation survey parties has shrunk materially from the time it was dumped loosely in the car at the pit, measured and paid for.

"It is the amount of this shrinkage, expressed in per cent, that we are interested in and have endeavored to determine.

"There is little data on this subject, and the reason why so little of this data is available is because never before in the history of railroads in the United States has there been any necessity for any great amount of measurement of ballast by cross-sections in the field, as was the case when the Bureau of Valuation measured the ballast found in the track of the various carriers by taking cross-sections of the ballast. There are occasional instances where ballast has been measured in track after being in use for a sufficient period to be considered seasoned, but these cases are very rare.

"In addition to this, in practically all track in the United States, ballasting has been done piecemeal. Sometimes the original ballast was what is known as 'cementing gravel' or sometimes cinder. On top of this in many cases has been placed a better grade of gravel or washed gravel. Later, on top of this has been placed crushed stone. No record has been kept of the yardage of ballast bought and paid for to build this track, or, if it has been kept, no record of where it was placed in the track has been kept. Therefore, in practically the entire mileage of the railroads of the United States there is no way to measure this shrinkage, and this accounts for the small amount of data on this subject.

"So far as the carriers have been able to find out, no previous tests of any such magnitude as we have attempted to make have ever been made. It is clear from the data which we have that the shrinkage of stone ballast is approximately 16½ per cent. For chat and certain kinds of sand ballast the shrinkage may be less than 16½ per cent. For gravel, slag and cinder, the data indicates clearly a shrinkage in excess of stone ballast, and from the character of the material this is a reasonable conclusion; and it is safe to estimate that the shrinkage of gravel, slag and cinder is at least 20 per cent."

The Committee, therefore, attempted to prepare a specification for the establishing of test sections for the determining of shrinkage of ballast under traffic. This will be found in Vol. 30 of the Proceedings and was presented before the 1929 convention with the request for suggestions. This specification was sent out through the Secretary's office to the railroads with the request that such test sections be established. The response on the part of the railroads was not very promising and in the early part of 1930 a check was made of various projects in progress or about to be started by the

Tabulation Showing Progress of Ballast Shrinkage Tests

Test Number	Location	Length Feet	Test made on	Kind of Ballast	Specifications	Depth of Ballast Under Tie	Average Daily Tonnage (Tons)	Shrinkage per cent: Initial %	Shrinkage at the end of 1 Mos.	2 Mos.	3 Mos.	4 Mos.	5 Mos.	6 Mos.	7 Mos.	8 Mos.	9 Mos.	10 Mos.	12 Mos.	18 Mos.	24 Mos.	30 Mos.
1	Indiana	145.2	Conc. Pile B. D. Trestle	Lime-Stone	A.R.E.A. except min. size, limited to 2"	11"	46,500	13.70	16.33				18.18					18.67		19.59	20.90	23.29
2	Indiana	272.2	Conc. Pile B.D. Trestle	Lime-stone	do.	10½"	44,500	8.12		13.08				16.72					16.83	17.30	17.42	18.82
3	Indiana	406.3	Creo. B. D. Trestle	Lime-stone	do.	8"	44,450	14.40			18.30		22.00	22.00				22.50		21– 28–	25.8 26.1	36–26.7 42–27.14
4	Arizona	117.9	B. D. P. T.	Copper Smelter Slag	1" to 2"	7"	44,140	6.65	8.63	9.26	11.73	14.30	12.37	14.33	15.51					20–	18.23	
5	West Virginia	325.00	Old Seasoned Roadbed	Lime-stone	Max. size 2½"	4½"	42,000	22.6	33.5	37.40		37.6					37.7			11–	37.7	
6	Kansas	206.2	B. D. Truss Br.	Lime-stone	¾" to 2¼"	6"	87,500	16.5	17.1	17.9	18.1	18.4						18.6	18.8			
7	Kansas	208.8	B. D. Trestle	Lime-stone	¾" to 2¼"	8½"	18,460	12.1	14.9	15.1	17.5	17.3						20.0	20.0			

railroads, upon which such test sections might be installed and the attention of the respective roads called to the fact. There was no better response and the Committee has therefore been unable to get as much information as is desirable. The Committee, however, wishes to take this opportunity of thanking those roads that cooperated with them and established the test sections.

There is attached hereto in tabulated form the results of the tests which have been installed.

Conclusions

The Committee believes that it has done all it can on this subject unless some of the railroads will establish additional test sections. The Committee does not feel justified in drawing any conclusions or making any definite recommendations for with the variability of conditions and the complexity of the problem, the results of a few tests may be misleading. Conclusive statements may be made only after repeated work under a variety of conditions and a careful comparison and study of all the information available. A sufficient number of repetitions of a test must generally be made to bring the error of observation within reasonable limits.

Appendix D

(5) COMPARATIVE COSTS OF MAINTAINING TRACK ON VARIOUS KINDS OF BALLAST

Daniel Hubbard, Chairman, Sub-Committee; C. E. Dare, H. B. Christianson, A. D. Kennedy, S. H. Osborne, J. A. Snyder, H. E. Tyrrell, C. H. Zentmyer.

In connection with this subject, questionnaire was sent out by the Secretary to all Class I railroads and it was rather disappointing to find that there was only one railroad which could give any accurate detailed figures on the subject.

Your Committee has confined its work to obtaining available data on only two kinds of ballast, viz., stone and gravel. The figures given below represent actual cost data as kept over a period of four years, the fifth year was available too late to include in the report.

Physical characteristics, number of trains, and tonnage are identical on these two sections of track, therefore, the comparison should be of considerable value.

Comparative reports are being kept and worked up over additional miles of trackage and it is recommended that the study be continued for another year. It is doubtful, however, if actual costs can be developed on other kinds of ballast unless some other railroads can furnish the data.

THE NORTH AND SOUTH RAILWAY COMPANY

STANDARD MILE—BETWEEN MILE POST 581 AND 582

West Division — STONE BALLAST — EAST DISTRICT

	1927					1928				
	Units	Man Hours	Labor Cost	Material Cost	Total Cost	Units	Man Hours	Man Cost	Material Cost	Total Cost
TIE RENEWALS										
Digging in—Each						3	2	.81	4.35	5.16
With Raise—Each	55	81	12.44	117.59	130.03					
Switch—Lin. Ft.						1391	167	67.67	310.38	378.05
RAIL RENEWAL										
Repair										
OTHER TRACK RENEWALS										
Tie Plates	3897	501	201.12	963.28	1164.40					
Miscellaneous							18	5.27	3.00	8.27
BALLAST										
Cleaning Yd.										
Stone Yd.	2524	3354	1346.40	1640.60	2987.00	144	427	173.03	108.00	281.03
LINE AND SURFACE										
Main Track—Ft.	3815	614	246.48		246.48	14418	612	247.99		247.99
Respace Ties	774	75	30.11		30.11					
Regauging Ties	358	27	10.84	3.73	14.57	200	24	9.73	11.45	21.18
Tighten Bolts						570	19	7.70	1.75	9.45
Roadway										
Banking Ft.	9644	1585	636.26		636.26	585	26	10.54		10.54
Ditching Ft.	468	20	8.03		8.03	450	18	7.29		7.29
Cleaning						17420	292	118.32		118.32
Mowing							206	83.48		83.48
Cut Brush							16	6.48		6.48
Repair Switches							93	37.68		37.68
Oil Joints						810	25	10.13	1.35	11.48
Snow and Ice							14	5.68		5.68
Patrolling							187	75.77		75.77
Undistributed		621	249.17		249.17		123	49.84		49.84
Total		6828	2740.85	2725.20	5466.05		2264	917.41	440.28	1357.69
Av. Hourly Rate					0.4014					0.4052

West Division

The North and South Railway Company
STANDARD MILE—BETWEEN POST 581 AND 582
Stone Ballast

East District

	1929					1930				
	Units	Man Hours	Labor Cost	Material Cost	Total Cost	Units	Man Hours	Man Cost	Material Cost	Total Cost
TIE RENEWALS										
Digging in—Each										
With Raise—Each	503	214	87.53	646.36	733.89					
Switch—Lin. Ft.	52	4	1.64	2.17	3.81					
RAIL RENEWALS										
Repair						156	19	7.87	75.45	83.32
OTHER TRACK RENEWALS										
Tie Plates										
Rail Joints	45	35	14.36	62.10	76.46					
Frogs						1	27	11.18	122.00	133.18
Miscellaneous		6	2.45	20.04	22.49		87	15.32	28.72	44.04
BALLAST										
Cleaning Yd.	206	313	128.02		128.02	157	277	114.68		114.68
Stone Yd.	125	452	184.87	100.00	284.87					
Gravel Yd.	1085	1982	810.64	651.00	1461.64					
LINE AND SURFACE										
Main Track—Ft.	16648	1134	463.81		463.81	18710	1062	439.68		439.68
Respace Ties	1797	132	53.99		53.99					
Regauging Ties	367	30	12.27	10.94	23.21	176	14	5.80	1.28	7.08
Tighten Bolts	2072	55	22.49	3.63	26.12	5798	93	38.50	3.53	42.03
Roadway										
Banking Ft.	5126	582	238.04		238.04	4220	1004	415.66		415.66
Ditching Ft. Drain	48	102	41.72	25.00	66.72	623	54	22.36		22.36
Cleaning	36667	540	220.86		220.86	39872	470	194.58		194.58
Mowing		169	69.12		69.12		156	64.58		64.58
Repair Switches		84	34.86		34.86		121	50.09	1.00	51.09
Oil Joints	521	19	7.77	1.00	8.77	587	18	7.45	2.25	9.70
Snow and Ice		40	16.86		16.86		6	2.48		2.48
Patrolling		204	83.44		83.44		191	79.07		79.07
Undistributed		48	19.68		19.68		38	15.78		15.78
TOTAL		6145	2513.37	1522.24	4035.61		3587	1485.03	234.23	1719.26
Ave. Hour Rate					0.4090					0.41400

The North and South Railway Company

STANDARD MILE—BETWEEN MILE POST 625 AND 626

East Division — Gravel Ballast — West District

	1927						1928					
		Man Hours	Unit Cost	Material Cost	Labor Cost	Total Cost	Units	Man Hours	Unit Cost	Material Cost	Labor Cost	Total Cost
Ties Digging in												
Ties with Raise	A388		2.045	777.43	123.11	900.54						
Ties Switch							80	8	.23	6.90	3.23	10.13
Tie Plates							X90		.108	9.45		9.45
Rail Joints							X20		.106	21.20		21.20
Ballast Gravel	10560		.800	3168.00	2534.32	5702.32	156	26	.154	24.00	10.50	34.50
Ballast Cleaning	46				45.35	45.35						
L & S Main Track							7096	581			234.73	234.73
Respacing Ties	6008				169.62	169.62						
Regauging Ties	B 4794		.015	69.75	149.57	219.32						
T & R Bolts							1134	15			6.06	6.06
Guard Rails							1	20	19.85	19.85	8.08	27.93
Banking	11482				1108.67	1108.67	4073	848			342.59	342.59
Ditching	429				32.08	32.08	1170	118			47.67	47.67
Cleaning R/W							3000	44			17.78	17.78
Mowing							21120	291			117.56	117.56
Weeding							21120	321			129.68	129.68
Tapping Spikes							100	16			6.46	6.46
Repairing Crossings							6	90	7.38	44.28	36.36	80.64
Snow and Ice							40	16			6.46	6.46
Superficial Dressing							13162	212			85.65	85.65
Switch Stands							1	9	14.85	14.85	3.64	18.49
Oiling Bolts							3264	29	.08	1.28	11.72	13.00
Spikes							X 1		5.65	5.65		5.65
Bolts							X 64		.06	3.84		3.84
Patrolling							2	299			120.80	120.80
Miscellaneous					202.72	202.72				.15		.15
Salvage												
Total Less Salvage				4015.18	4365.44	8380.62		2943		151.45	1188.97	1340.42
Av. Hourly Rate							.404					

A includes 776 tie plates and 3 kegs spikes. B includes 9 kegs spikes and 21 bags tie plugs. X indicates used when laying rail.

THE NORTH AND SOUTH RAILWAY COMPANY

STANDARD MILE—BETWEEN MILE POST 625 AND 626

East Division — GRAVEL BALLAST — WEST DISTRICT

	1928						1930					
		Man Hours	Unit Cost	Material Cost	Labor Cost	Total Cost	Units	Man Hours	Unit Cost	Material Cost	Labor Cost	Total Cost
Ties Digging in	30	62	1.38	41.40	25.22	66.62	30	30	1.38	41.40	12.36	53.76
Ties with Raise												
Ties Switch												
Tie Plates	88		.13	11.44		11.44						
Rail Joints	5		1.06	5.30		5.30						
Ballast Gravel	2890	415	.036	104.00	168.91	272.91						
Ballast Cleaning												
L & S Main Track	27607	1262			513.63	513.63	14484	812			334.54	334.54
Respacing Ties							1298	91			37.49	37.49
Regauging Ties	13	1			.41	.41	1488	97	.90	1.80	39.96	41.76
T & R Bolts	1400	18			7.33	7.33	1200	16			6.59	6.59
Guard Rails												
Banking	2645	390			158.73	158.73	760	148			60.98	60.98
Ditching	1412	85			34.60	34.60	565	42			17.30	17.30
Cleaning R/W	4453	109			44.36	44.36	15260	149			61.39	61.39
Mowing	23462	306			124.54	124.54	21120	168			69.22	69.22
Weeding	23786	330			134.31	134.31						
Tapping Spikes	579	36			14.65	14.65	91	8			3.30	3.30
Repair Crossings	4	46			18.72	18.72						
Snow and Ice	144	200			81.40	81.40	100	72			29.66	29.66
Superficial Dressing	7670	135			54.95	54.95	4416	130			53.56	53.56
Oiling Bolts	2160	18	.08	.96	7.33	8.29	1884	8	.08	.32	3.30	3.62
Spikes							1		5.65	5.65		5.65
Bolts												
Patrolling	2	299			121.69	121.69	2	299			123.19	123.19
Miscellaneous		44			17.91	17.91		56			23.07	23.07
Salvage				26.20		26.20				1.00		1.00
Total Less Salvage		3756		136.90	1528.69	1665.59		2126		48.17	875.91	924.08
Av. Hourly Rate	.407						.412					

Appendix E

(6) DETERMINE PROPER DEPTH AND KIND OF BALLAST

The Committee in studying this subject sent out the following questionnaire to railroads in the United States and Canada:

1. Is it the practice to differentiate between sub-ballast and top-ballast?
2. What are the relative proportions of top-ballast and sub-ballast?
3. Is sub-ballast used on all classes of roadbed or is its use confined to any particular class of roadbed?
4. Is sub-ballast used only in connection with the construction of new tracks or is it ever considered in connection with re-ballasting?
5. What are the special results expected to be obtained from the use of sub-ballast?
6. Give the ballast section used separating between top-ballast and sub-ballast. If you have a plan of your ballast section, please send a copy.
7. Is the depth varied with different kinds of material in the roadbed?
8. Is it expected that sub-ballast will be driven into the roadbed, gradually becoming a part of same?
9. Is sub-ballast ever used to cure soft places in roadbed?
10. If so, what determines the depth to be used?
11. Give personal opinion of the merits of sub-ballast and a comparison of the depth that should be used.

Replies were received from roads representing 158,000 miles from various sections of the country. It is not feasible to tabulate the replies to the above questionnaire, but the following statements, although brief, are a summary and denotes the concensus of opinion:

1. The majority of the roads differentiate between top-ballast and sub-ballast. This is especially noticeable on those roads carrying the heaviest traffic. There are some roads, where due to local conditions brought about largely by the source of ballast, that do not differentiate, but even these secure practically the same results by levelling the ballast to the bottom of the ties at more or less regular intervals and then applying new ballast.
2. The proportions between top-ballast and sub-ballast varied for top-ballast from 6 inches to 18 inches in depth and for sub-ballast from 8 inches to 12 inches. On a percentage basis the proportion for top-ballast was 40 to 60 per cent and for sub-ballast 33 to 50 per cent.
3. The general practice is to use sub-ballast followed by top-ballast on all main line construction, especially on new work.
4. Few consider the use of sub-ballast on anything but new construction unless it is desired to help correct some condition particularly in the roadbed.
5. The "results expected" are better drainage, a more uniform distribution of the load over the roadbed, acting as a cushion between the top-ballast and the roadbed, thereby preventing the roadbed material working up into the top-ballast, more economical, as cheaper material can be used for sub-ballast than is usually required for good top-ballast. Some roads that did not use sub-ballast at the time of construction of main line tracks have experienced considerable difficulty in maintaining line and surface. They have tried various remedies and at last resorted to the method of applying a sub-ballast by cleaning out everything for some distance below bottom of tie, applying sub-ballast and later raising to grade on top-ballast.

A Chief Engineer of one of the large systems writing on this subject, stated: "In regard to the use of sub-ballast, it has been my experience that cinders, limestone screenings, cementing gravel or a pit-run loose gravel with a considerable quantity of sand will make satisfactory sub-ballast, and in all new construction work it has been our practice to use whichever one of these types of material most easily available on the

new embankments, using ten to twelve inches, with the thought that at some subsequent date a more substantial quality of ballast such as slag, crushed stone or washed and crushed gravel, can be applied."

6. This is largely covered in Question 2.

7. The majority make no variation although some vary according to the kind of material in the roadbed and the condition of the roadbed.

8. The majority are of the opinion that the sub-ballast is driven down into the roadbed, although some of the large systems feel that by using the proper depth of sub-ballast, a distribution of the load would be such that the sub-ballast does not become an integral part of the roadbed, but serves as a cushion between the roadbed and the top-ballast.

9. Used at times by some roads, but when so used it is not generally classed as sub-ballast.

10. and 11. Are generally covered in the preceding answers. To confirm the need of sub-ballast, a few typical replies are quoted below:

"There is no question in our minds but what the value of sub-ballast is well-established and we believe that a minimum of twelve inches is essential."

"Unless the sub-grade is always hard and free from water, it is desirable to have at least one foot of sub-ballast under the top-ballast. A greater depth is often valuable. Top-ballast is likely to run from one-third to one-half of total ballast."

"This whole question depends upon the class and character of the track and the weight and volume of traffic to be supported; the materials in the sub-grade and the sub- and top-ballast; drainage, etc. To have ideal conditions, to give minimum maintenance cost, you should have drainage so that the top of the sub-grade is always comparatively dry or is drained out quickly after rains, etc. Where ideal drainage is available or provided, less ballast may be used. Where it is not practicable to have drainage or the sub-grade materials are such that this cannot be kept reasonably dry and firm at all times, additional depths of ballast are required to prevent the accumulation of water within a space of at least two feet below the top to avoid heaving on account of frost, etc."

The Committee concludes that many materials such as sand, pit run gravel, stone, screens, slag and cinders are used with satisfactory results as sub-ballast, and the Committee is not in a position to recommend any of these materials in preference to the other as availability of supply will be the determining factor for use.

The Committee feels that ballast materials of smaller aggregates than may be proper for top-ballast, are more suitable for sub-ballast, than ballast materials of larger aggregates, such as broken stone and crushed slag. Sub-ballast should consist essentially of relatively small aggregates as such material has a tendency to prevent the roadbed material working up into the top-ballast.

The Committee cannot definitely determine the proper depth of sub-ballast as this is governed by the nature of the roadbed, the total depth of ballast used, character of the track, volume and nature of traffic handled. For the reasons set out in the preceding paragraphs, it is the opinion of the Committee that a combination of top- and sub-ballast will, with few exceptions, give better results than to use the straight top material for the entire depth.

On page 93 of the 1929 Manual, sub-ballast is defined as follows: "Any material of a superior character, which is spread on the finished sub-grade of the roadbed and below the top-ballast, to provide better drainage, prevent upheaval by frost and better distribute the load over the roadbed."

Paragraph 4 under the heading "Proper Depth of Ballast," on page 102 of the 1929 Manual, reads as follows: "A combination of a good sub-ballast 18 to 14 in., and top-ballast 6 to 10 in., making a total of approximately 24 in. under the ties in the aggregate, will produce nearly the same result as though the superior material was used for the full depth."

The Committee concludes that paragraph 4 on page 102 of the 1929 Manual should be changed to read: "A combination of a good sub-ballast 18 to 6 in. and top-ballast 6 to 18 in., the total depth being dependent upon the volume of traffic and character of the roadbed, will produce better results than a superior material used for the full depth."

Recommendations

That the revision of paragraph 4 on page 102 of the 1929 Manual be adopted.

REPORT OF SPECIAL COMMITTEE ON WATER-PROOFING OF RAILWAY STRUCTURES

J. A. Lahmer, *Chairman;*
G. E. Boyd,
O. F. Dalstrom,
Hugo Filippi,
L. V. Haegert,
A. C. Irwin,
F. R. Judd,
A. H. Morrill,
G. A. Haggander, *Vice-Chairman;*
G. A. Rodman,
I. L. Simmons,
F. P. Turner,
L. W. Walter,
H. T. Welty,
C. A. Whipple,
Committee.

To the American Railway Engineering Association:

Your Committee presents herewith its report covering the following subjects:

(1) Definitions (Appendix A).

(2) When to waterproof or dampproof and methods to be used (Appendix B).

(3) Waterproofing and Dampproofing as applied to existing railway structures (Appendix C).

(4) Specifications for membrane waterproofing of concrete work excepting roofs of bridges. This subject is being considered by the entire Committee and has received the major portion of the Committee's time this year. Considerable information has been collected and draft of specifications prepared which it is hoped will be completed during the coming year.

Action Recommended

(1) That definitions which have been prepared be adopted for inclusion in the Manual.

(2) That subject be reassigned.

(3) That subject be reassigned.

(4) That subject be reassigned.

Respectfully submitted,

Special Committee on Waterproofing of Railway Structures,
J. A. Lahmer, *Chairman.*

Bulletin, 342, December, 1931.

Appendix A

(1) DEFINITIONS

F. R. Judd, Chairman, Sub-Committee; G. E. Boyd, O. F. Dalstrom, H. T. Welty.

It is recommended that the following definitions be adopted:

WATERPROOFING.—The treatment of any material or structure to prevent the entrance or passage of water or other liquid under head.

DAMPPROOFING.—The treatment of any material or structure to prevent the entrance or passage of water or other liquid not under head.

IMPERVIOUSNESS.—The quality of being completely resistant to penetration by water or other liquid.

INTEGRAL WATERPROOFING.—The process by which any admixture other than usual ingredients is added to a material in the process of manufacture for the purpose of increasing the watertightness of the product.

PRESSURE WATERPROOFING.—The process by which a material is forced into the pores or cracks or to the exterior or pressure side of a structure for the purpose of making it watertight.

MEMBRANE WATERPROOFING.—The application of alternate layers of fabric or felt, and bitumen to form a covering on a surface for the purpose of preventing the entrance of water or other liquid under head.

SURFACE COATING.—The application of a liquid by brush or spray for the purpose of waterproofing or dampproofing.

METALLIC WATERPROOFING.—The application to a surface of a mixture of a metal and a reagent, the chemical reactions of which tend to fill the pores.

Appendix B

(2) WHEN TO WATERPROOF OR DAMPPROOF AND METHODS TO BE USED

O. F. Dalstrom, Chairman, Sub-Committee; L. V. Haegert, A. C. Irwin, G. A. Rodman, I. L. Simmons, C. A. Whipple.

Committee is not ready to make a report except that subject is receiving attention and it is recommended that subject be reassigned for further study.

Appendix C

(3) WATERPROOFING AND DAMPPROOFING AS APPLIED TO EXISTING RAILWAY STRUCTURES

Hugo Filippi, Chairman, Sub-Committee; G. A. Haggander, A. H. Morrill, F. P. Turner, L. W. Walter.

Committee is considering information collected by Committee on Buildings, and recommends that subject be reassigned for next year.

REPORT OF SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK

A. N. Talbot, *Chairman;*
W. M. Dawley, *Vice-Chairman;*
C. B. Bronson,
John Brunner,
W. J. Burton,
Chas. S. Churchill,
W. C. Cushing,
Robert Faries,
C. W. Gennet, Jr.,
H. E. Hale,
J. B. Jenkins,
George W. Kittredge,
Paul M. LaBach,
C. G. E. Larsson,
J. de N. Macomb,
J. V. Neubert,
G. J. Ray,
Albert Reichmann,
H. R. Safford,
Earl Stimson,
F. E. Turneaure,
J. E. Willoughby,

Committee.

To the American Railway Engineering Association:

The Special Committee on Stresses in Railroad Track, coöperating with a similar Committee of the American Society of Civil Engineers and with the American Railway Association, presents the following report of progress:

During 1931 the investigation of the Committee has been actively continued in the field, laboratory, and office. In September and October experimental work was conducted on the track of the Chesapeake & Ohio Railway near Ashland, Kentucky. Because of the nature of the problems under investigation and the need of obtaining stresses at a large number of gage lines on both rail and joint bars and at places that would be inaccessible with other forms of instruments, static loading with freight cars was used in the tests and the Berry strain gage was used in measuring stresses, thus simplifying the testing operations. The track was equipped with 130-lb. R.E. rail. The joint bars were of a type approaching a symmetrical section and had a length of 39 in. The tests on rail-joints thus gave opportunity to make comparison with forms of rail-joints already tested and to determine the bending moments developed in the rail-joints as related to those in the full rail and to measure the fit and vertical movement between rail and joint bars, the vertical and lateral flexure of the joint bars, and the deflection of the rail-joint as compared with the full rail. The stresses in joint bars were measured at various gage lines to find the distribution of stress and moment along the length of the joint bar. Other important measurements included track depression with heavy, medium, and light loads, the vertical play between rail and tie and tie and ballast bed at consecutive ties along the rail, and stresses in rail at nearby points in an effort to correlate the marked differences in stresses, play, tie depression, and tie loads from tie to tie along a rail, data being taken at various locations along the track.

Tests were made in October on the track of the Missouri Pacific Railroad near Middlebrook, Missouri, on a stretch of so-called GEO track laid with 110-lb. R.E. rail with a view of learning some of the characteristics of the track action in this form of construction. The ties had been preadzed and prebored. Static loading with heavy and light freight cars was used in the tests. Measurements were made to determine vertical movement between rail and tie-plate, tie-plate and tie, and tie and ballast bed upon application of load. Determination was also made of the depression of track from point to point along the rail, of the variation in load taken by individual ties and the variations in stress in rail from point to point along a rail, and of the amount of upward movement of the rail away from the wheel load. From these data it is expected that a comparison can be made between the action of this track and that of other

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forms of construction which may answer some of the questions arising in the mind of the track engineer. These tests were not comprehensive but were in the nature of a reconnaissance.

The laboratory experimental work, conducted from time to time during the year on several forms of rail-joints, has been planned to supplement and aid in the interpretation of field test data.

In the office, the reduction of data obtained at the tests on the Chesapeake & Ohio Railway and the Missouri Pacific Railroad is in progress and studies are being made on the interpretation of results and the manner of presentation in making up a report. The reduction of data of the tests on the Pennsylvania Railroad at Claymont, Delaware, made in 1930, is well along and the form of presentation is being co-ordinated with the field work made during this season and with the laboratory tests.

The study of the experimental data has not progressed far enough to permit a detailed report to be made.

Attention is called to the paper on "Rail Stresses and Locomotive Tracking Characteristics Found in Tests on the Great Northern Railway" by J. Paul Shamberger and B. F. Langer, Engineers of the Westinghouse Electric and Manufacturing Company, published in Bulletin No. 339 of the Association (September, 1931). This report of tests made by Westinghouse Engineers is a valuable contribution to several aspects of the interrelation between locomotive and track on tangent and curved track with particular reference to variations in the vertical and horizontal loads exerted by individual wheels on the rails of curved track, as found with several types of locomotives including both steam locomotives and electric locomotives. The methods and instruments used were novel and ingenious. The paper brings out analyses and relations that should be useful in considering the interrelation of track and locomotive design. The Chairman of the Committee was given the opportunity to make a study of the manuscript in its preliminary form and offered a number of suggestions for its presentation and publication. The paper should be helpful to engineers interested in judging of the action of locomotives as well as for aiding in their design.

Respectfully submitted,

THE SPECIAL COMMITTEE ON STRESSES IN RAILROAD TRACK,

A. N. TALBOT, *Chairman.*

REPORT OF COMMITTEE XXII—ECONOMICS OF RAILWAY LABOR

F. M. Thomson, *Chairman;*
R. B. Ball,
J. J. Baxter,
G. A. W. Bell, Jr.,
W. R. Bennett,
T. S. Bond,
A. E. Botts,
N. W. Brown,
H. A. Cassil,
J. F. Dobson,
John Evans,
J. A. Gorr,
Paul Hamilton,
H. H. Harsh,
H. I. Hoag,
C. H. R. Howe,
E. T. Howson,

Lem Adams, *Vice-Chairman;*
J. H. Kelly,
C. R. Knowles,
F. J. Meyer,
G. M. O'Rourke,
J. A. Parant,
C. H. Paris,
J. C. Patterson,
D. M. Rankin,
A. N. Reece,
F. R. Rex,
F. S. Schwinn,
William Shea,
H. M. Stout,
G. M. Strachan,
Cale Wamsley,

Committee.

To the American Railway Engineering Association:

Your Committee presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A). No revisions are recommended.

(2) Analysis of operations of railways that have made marked progress in the reduction of labor required in maintenance-of-way work (Appendix B).

Recommended that the report be received as information and the subject continued.

(3) Effects of recent developments in maintenance-of-way practices on gang organization (such as use of heavier rail, treated ties, and labor-saving devices, which make practicable small section forces, and conducting the major part with extra gangs) collaborating with Committees I—Roadway, II—Ballast, III—Ties, IV—Rail, V—Track, and XVII—Wood Preservation (Appendix C).

Recommended that the report be received as information, the conclusions approved for publication in the Manual, and the subject continued.

(4) Investigation and report on the merit of annual maintenance inspection, including prize awards, the use of track recording cars and machines and best methods of utilizing records secured from such inspection (Appendix D).

Recommended that the report be received as information, the conclusions approved for publication in the Manual, and the subject discontinued.

(5) Relative economies of brush versus spray painting (Appendix E).

Recommended that the report be received as information, the conclusions approved for publication in the Manual, and the subject discontinued.

(6) Revised plans for outfit cars for maintenance-of-way department employees, collaborating with Division V—Mechanical, A.R.A. (Appendix F).

Recommended that the report be received as information and the subject continued.

(7) Economics of methods of weed killing (Appendix G).

Recommended that the report be received as information and the subject continued.

(8) Use of motor trucks in maintenance-of-way and structure work (Appendix H).

Recommended that the report be received as information and the subject continued.

(9) Gang organization and methods of performing the more common tasks of maintenance-of-way work, including the revision of the time studies now in the Manual to bring them in accord with modern mechanical methods (Appendix I).

Recommended that the report be received as information and the subject continued.

Respectfully submitted,

The Committee on Economics of Railway Labor,

F. M. Thomson, *Chairman.*

Bulletin 343, January, 1932.

Appendix A

(1) REVISION OF MANUAL

John Evans, Chairman, Sub-Committee; Lem Adams, T. S. Bond, G. M. O'Rourke, A. N. Reece, H. M. Stout, Cale Wamsley.

No revision of Manual is recommended.

Appendix B

(2) ANALYSIS OF OPERATIONS OF RAILWAYS THAT HAVE MADE MARKED PROGRESS IN REDUCTION OF LABOR REQUIRED IN MAINTENANCE OF WAY WORK

J. A. Parant, Chairman, Sub-Committee; H. A. Cassil, J. A. Gorr, Paul Hamilton, E. T. Howson, F. J. Meyer, J. C. Patterson, H. M. Stout.

Following the assignment of this subject to your Committee in 1929, a survey was first made to ascertain those roads which had made the most marked reductions in the amount of labor expended for maintenance of way, and as a result of this survey, the Lehigh Valley was selected for first consideration.

This road was chosen because of the outstanding reductions that it had made in the amount of labor expended on the upkeep of its property over a period of years, and the fact that these activities had not been complicated by the presence of a heavy improvement program. It was also felt that it was advisable to select for first investigation a road of moderate size and with the minimum complications.

In its study of the records of this road, it has attempted to allocate the reductions in man-hours, so far as this is possible from available records, to individual changes in methods, standards, materials, labor-saving equipment, etc., to determine the extent to which these various influences have contributed to the decrease. Where it has not been possible to analyze and assign man-hour savings to individual changes in practice or methods, an endeavor has been made to bring together those combinations of practices, methods or materials which effected the saving and to allocate a reduction in man-hours to this collective influence.

Although the Committee's assignment deals with man-hours, it has also been necessary at times to fall back on the actual expenditures of the road in order to develop the necessary comparisons.

It has been necessary in numerous instances for the Committee to make certain assumptions preliminary to the analysis of a particular operation, a defect which it recognizes and which it believes inescapable. Its only request is that those who challenge its assumptions shall substitute more accurate assumptions therefor.

In the report which follows the Committee has endeavored to measure the influence of the more important practices which have been put into effect on the Lehigh Valley, the results of which have become evident during the period under consideration.

The following statement shows the total man-hours for maintenance of way, and also that portion of its labor devoted to current repairs by the maintenance of way department from 1915 to 1930, together with the ratio which the man-hours of each year bear to the average for the test period, or the period from 1915 to 1917, inclusive, which the United States Railroad Administration selected as the basis for comparison with the period of government control.

STATEMENT A—COMPARISON OF MAN-HOURS, MAINTENANCE OF WAY, LEHIGH VALLEY RAILROAD COMPANY

Year	*Total Man Hours*	*Man Hours for Current Repairs only*	*Man Hours Per miles of Trk. Current Repairs*	*Ratio Man Hours for Current repairs each year to those of test period*
Test Period Av.	10,496,749	9,975,344	2960	100.0
1918	12,019,047	11,629,549	3420	116.6
1919	10,481,152	10,339,444	3050	103.6
1920	11,430,165	11,245,834	3310	112.7
1921	8,782,642	8,709,497	2560	87.3
1922	8,776,115	8,680,787	2550	87.0
1923	8,577,948	8,471,137	2480	84.9
1924	8,568,190	8,441,825	2470	84.6
1925	8,239,708	8,104,051	2370	81.2
1926	8,032,883	7,894,186	2310	79.1
1927	7,665,376	7,426,245	2170	74.4
1928	6,076,400	5,675,413	1660	56.9
1929	5,898,885	5,590,042	1630	56.0
1930	5,180,400	4,822,300	1410	48.4

Although there is a reduction of 51.6 per cent in the man-hours for 1930, as compared with the test-period average, the year 1929 will be used as more representative of normal railway conditions.

Savings Effected in Man-Hours by Use of Treated Ties

There is no operation where the labor-saving is as clean-cut as in the case of the use of treated ties, after reaching a certain per cent in track, and yet in this case the savings become involved to an extent with rail, tie plates, treatment, kind of ties, etc.

Approximately 82 per cent of the cross-ties in track on this railway are treated, this percentage having been attained after 20 years. Wherein the renewals reached the abnormally low figure of 48 per mile of track in 1929, it is believed that the ultimate renewals will not exceed 100 per mile.

Tie renewals are brought about through the combination of two causes—(1) use or mechanical wear; (2) causes other than use, which includes deterioration, derailments, etc. When compared with the other causes, the renewals through derailment are small relatively, and, therefore, for the purpose of this analysis, only the two main causes will be considered.

Chart No. 1 has been developed in an endeavor to separate to an extent as between the effect of treatment of ties and the reduction in mechanical wear due to the use of large tie plates, heavier rail, etc. The chart shows the tie renewals and per cent of treated ties in track on the Lehigh Valley and one other railway both with standards of 136 lb. and 130 lb. rail, respectively, and both using plates measuring close to 8 in. × 13½ in. in area as compared with the average for other railways with the same relative percentage of treated ties in track.

It will be noted that the renewals on the Lehigh Valley during the last six years, or from 1924 to 1929 inclusive, averaged 80 per mile, with an average of 76 per cent treated ties in tracks. In the case of the other railway the renewals averaged 90 per mile with an average of 88 per cent treated ties in track.

Reading directly from the chart, the average renewals for all roads with 76 per cent treated ties in track approximates 148, whereas, as stated above, the Lehigh Valley renewals with 76 per cent treated is 80, or a difference of 68 ties per mile. In the case of the other property with 88 per cent treated ties the chart shows 116 renewals per mile against actual renewals on that property of 90, or a difference of 26 ties per mile.

Insofar as the average density of traffic per mile is concerned the Lehigh Valley has 38 per cent more than the average for the railways making up this chart, whereas in the case of the other railway the density is 89 per cent above the average.

The tie renewals for the test period averaged 294 per mile. In 1929 the renewals were 48 to the mile, or a difference of 246 ties. Applying this reduction per mile to the 3428 miles of track on the system effects a yearly reduction in the total renewals of 843,288.

It may be proper to state at this point that the Lehigh Valley does not claim that this abnormally low tie renewal of 1929 will continue; furthermore, the Committee is endeavoring to explain and allocate man-hour reductions and not ties. However, it is necessary for the Committee to recognize these figures in order to make this allocation and distribution of the reduction in man-hours when comparing years.

As stated previously and as shown on Chart No. 1, the Lehigh Valley shows 68 less tie renewals than the average of other railways with 76 per cent of their ties in track, treated. It is not the Committee's claim that this entire difference can be attributed to the reduction in mechanical wear due to the 8 in. × 13½ in. tie plate, but it is the feeling that the major part is due to this, followed by the heavier rail of greater girder strength, the use of hardwood ties on sharp curves, together with the effect of careful original treatment, proper spotting, care in track, the use in light traffic side-tracks of those treated ties removed with some remaining life, and the reduced gaging of track required.

A conservative estimate of the amount of labor required to install a tie based on the traffic and per cent of rock ballasted track would be one (1) man-hour or 8 ties per man-day of 8 hours. Separating the 246 reduction in the renewals per mile as between those which may be assigned to treatment and those due to using a large plate, results in allocating 178 to treatment and 68 to the reduction in mechanical wear. Transposing this into man-hours by multiplying by the mileage and one (1) hour per tie renewed results in the following:

Treated	3428 miles × 178 ties × 1.0 M.H. —	610,184 man-hours
Reduction in mechanical wear	3428 miles × 68 ties × 1.0 M.H. —	233,104 man-hours
Total Man-Hour Reduction Cross-Ties		843,288 man-hours

In addition to the saving in man-hours from the installation standpoint, a saving in the labor of distribution as it affects the maintenance of way hours should be added. To distribute and pile ties when necessary will conservatively average one-tenth man-hour per tie. Based on the reduction in renewals per year of 843,288, the savings in distribution at one-tenth man-hour per tie equals 84,329 man-hours.

No consideration is given in this study to the man-hour savings that are effected in the stores department in the handling, storing or loading of ties, which saving without question is material, especially on those railways doing their own treating.

Switch Ties

The average switch tie renewals for the test period equalled 2,168,000 F.B.M., whereas in 1929 the renewal was 524,000 F.B.M., or a difference of 1,644,000 F. B. M. The labor necessary for installing a thousand feet of switch timber, including unloading and placing, will approximate 35 man-hours, resulting in a total saving from this cause of 57,540 man-hours.

Bridge Ties

Bridge tie renewals in the test period averaged 867,000 F.B.M. per year, whereas in 1929 the renewals were 60,000 F.B.M., a difference of 807,000 F.B.M. This reduction

in renewals resulted in a saving of approximately 40 man-hours per thousand board measure or 32,280 man-hours.

Summary of Man-Hour Savings Through Reduction in Tie Renewals

Man-hour savings by treatment	610,184 man-hours
Man-hour savings reduction in mechanical wear	233,104 man-hours
Man-hour savings in tie distribution	84,329 man-hours
Man-hour savings use of treated switch ties	57,540 man-hours
Man-hour savings use of treated bridge ties	32,280 man-hours
Total	1,017,437 man-hours

Savings Effected in Man-Hours by Use of Heavier Rail

The first part of this analysis deals with the saving in man-hours from the standpoint of the reduction in the average tonnage of rail used on the Lehigh Valley, whereas the second part deals with the savings in connection with the changes in methods of laying.

Since 1916, only 136 lb. rail has been purchased by the Lehigh Valley. For the 11-year period from 1905 to 1915 inclusive the new rail laid per year averaged 20,725 tons. Since 1916, the renewals have averaged 17,500 tons per year. Transposed into miles of track, this tonnage is equivalent to an average per year of 131 track miles of 100 lb. rail prior to 1916 and 82 miles of 136 lb. rail subsequent to 1916, or a difference of 49 miles. The density of traffic is slightly greater in the latter periods.

Under present-day methods with full use of equipment and diverting of traffic when laying rail, the man-hours required to lay one mile of track approximate 1100. Insofar as the distributing and picking up of the rail and material are concerned, the present methods are similar to those used in the test period; in other words, rail was distributed and picked up at that time by either crane or air hoists. Without full use of such equipment as cranes, compressors, bolt runners, spike drivers, adzers and spike pullers, together with the diverting of traffic, which is necessary if equipment is to be used effectively, the time required to lay one track mile of rail approximates 2300 man-hours, having in mind the fact that with equipment the weight of the rail has no effect on the man-hours required to lay it, whereas such is not the case with hand laying.

The saving in man-hours per year by reason of the lesser average mileage of rail now being relaid is, therefore, 49 miles @ 2300 man-hours per mile or 112,700.

It naturally follows that if the average tonnage of new rail laid is reduced, the same will apply to the relaying of that rail which it replaces. As approximately 75 per cent of the rail replaced with new rail is relaid, it is conservative to estimate a further saving of at least 75 per cent of the 49 miles or 37 miles which, at 2300 man-hours per mile, is equivalent to 85,100 man-hours more.

In addition, the mileage of new rail being laid, an average of 82 miles, is laid by equipment and the diverting of traffic with 1200 man-hours less labor per mile amounting to 98,400 less man-hours.

By the same token, at least, 40 per cent of the 82 miles, or 33 miles, is relaid in lines where equipment can be used, which develops a saving in man-hours of 33 $\times$ 1100 or 36,300 man-hours.

A still further saving in man-hours is developed by the lesser mileage of rail and track material distributed and picked up. Distributing of rail and fastenings require approximately 210 man-hours per mile and picking up close to 175 man-hours, or a total for both operations of 385 man-hours. The reduction in the miles of new rail is 49 and of relay 37, or a total of 86 miles, which at 385 man-hours per mile, is equal to a reduction of 33,110 man-hours.

Summary of Man-Hour Savings Through the Reduction in the Average Mileage of Rail Laid by Using Heavier Rail and Through the Use of Equipment and Diversion of Traffic

Man-hour savings through laying heavier rail	(new)	112,700 M.H.
Man-hour savings through laying heavier rail	(relay)	85,100 M.H.
Man-hour savings through full use of equipment, etc.	(new)	98,400 M.H.
Man-hour savings through full use of equipment, etc.	(relay)	36,300 M.H.
Man-hour savings in lesser mileage of distribution and picking up..		33,110 M.H.
Total		365,610 M.H.

There is a further saving in man-hours by reason of the building up and reconditioning of rail ends, although this is partly offset by the man-hours necessary to perform the operation. The major saving from this operation is evident in the life added to the rail, which is reflected to a greater degree in the average expenditure for rail than in man-hours.

Analysis of Forces on M. of W. Work

Chart No. 2 shows the total man-hours of section and extra crew laborers, together with the man-hours per mile of track for these forces. It will be noted that there has been a marked reduction in section laborers since the test period. Whereas the extra crew laborer hours show a reduction, it is small in proportion to the reduction in section forces.

Chart No. 3 shows graphically the man-hours for section foremen and signalmen and maintainers. Whereas the section foremen hours show an upward trend in 1922 and 1923 over 1921, this can be attributed to a 10-hour day through the summer as there was no appreciable change in the number of men or sections. From 1923 to 1927 inclusive the hours were practically constant. In 1928 a marked drop in hours will be noted, followed by a further reduction in 1929. During this period the number of maintenance sections was reduced from 306 to 243 or 26 per cent and the section foreman man-hours 25 per cent.

Referring again to Chart No. 2, it should be borne in mind that the Federal control and guaranty period fell in the years 1918 to 1920 inclusive. In common with the other railways of the United States, the Lehigh Valley's man-hours were higher in this period than in previous or subsequent years. Furthermore, the year 1931 was one of labor adjustments and on many railways a period in which a part of the deferred maintenance of Federal control was made up. The year 1922 shows a marked reduction in man-hours and it can be stated conservatively that the difference in productivity of labor and changes in working conditions did as much to bring this about, when compared with previous years, as did any changes in methods of performing work or standards.

The Lehigh Valley was equipped with track motor cars prior to 1918 and the reflection of the savings through this cause cannot be considered in this study.

With respect to rock ballast, with the exception of resurfacing lifts, this ballast had been applied prior to 1908. Whereas the Committee believes that the effect of the 14 in. depth of ballast, together with its solidity due to the years of traffic, has its effect in reducing man-hours, together with the maintaining of this reduction, it is not possible to allocate definitely the savings to this item as it is felt that the reduction was effected to some major extent prior to the test period.

Regarding the reduction in man-hours due to the heavier rail section, it would seem that a statement of the Lehigh's present status as to rail in track might be in order. Approximately 42 per cent of all the main tracks of this railway are laid with 136 lb. rail. Taking the system as a whole, comprising 2051 miles of main track and 1378 miles

of yard and sidetracks, we find that 2366 miles are laid with rail weighing between 90 lb. and 136 lb. While this railway began installing 136 lb. rail in 1916, the Committee does not feel that it had any noticeable reflection in the labor hours until 1921 or 1922. However, from this time on the combination of heavy rail, fastenings, and fixtures had their effect, as will be observed on Charts Nos. 2 and 3.

A reduction in section laborer and foremen hours in 1928 was brought about by the lengthening of sections and this was made possible in turn by concentrating specialized extra crew forces in out-of-face surfacing and other general maintenance work. This general out-of-face work is performed every three to five years, depending upon the density of traffic, leaving the track in first-class shape for line, surface, etc. This results in curtailing the work required of the section forces to necessary spot surfacing, minor side-track work and other general duties. The general out-of-face work is done by mechanical tamping which gives more lasting results than the use of picks and section labor. To obtain the same relative results with section forces would necessitate the assignment of mechanical devices to individual sections. On the other hand, it is claimed that the cost with specialized crews is less and the investment in equipment is minimized.

It is the Committee's reaction that the combination of the rock ballast and heavy rail make it possible to maintain the surface, line and gage after the resurfacing for a period up to five years with the minimum hours of section labor. It is safe to state that the results now being obtained would be out of the question with light rail and poor ballast, under the present wheel loads, speed and density of traffic.

Reduction in Man-Hours Grading Account

For a number of years the Lehigh Valley has done extensive work in bank widening, ditching, sub-drainage, and slope cindering. The results from the expenditures for the work are very marked, as will be observed on Chart No. 4.

The charge to this account—Grading—in 1929 was $428,171 or about $124 per mile of all track. Comparing 1929 with 1921 it will be noted that there is a drop of 59 per cent in the charge to this account. Furthermore the downward tendency has been gradual over this whole period.

An analysis of the man-hours for grading shows that they are split up into four major operations, namely, ditching, care of roadbed, general cleaning and patrolling. The percentage of the total track man-hours that may normally be assigned to grading approximates 22 per cent made up as follows:

Ditching	3.0%	or	13.6%	of Grading Account
Care of roadbed	2.5%	or	11.4%	of Grading Account
General cleaning	10.0%	or	45.5%	of Grading Account
Patrolling	6.5%	or	29.5%	of Grading Account
Total	22.0%	or	100.0%	of Grading Account

The maintenance of way man-hours for current repairs on the Lehigh Valley for 1921, shown in statement at beginning of this report were 8,709,497, of which the 22 per cent applicable to the grading account totaled 1,916,090 hours.

If this assignment of man-hours to grading is broken down into its four parts the results are as follows:

Ditching	13.6% ×	1,916,090	M.H.	— 260,588	M.H.
Care of roadbed	11.4% ×	"	"	— 218,434	"
General cleaning	45.5% ×	"	"	— 871,821	"
Patrolling	29.5% ×	"	"	— 565,247	"
Totals	100.00%			1,916,090	"

Except in those sections of the property subject to slides or mine caveins, patrolling of track has been discontinued on the Lehigh Valley. It is the feeling that the major portion of the man-hours saved through this cause can be attributed to the combination of the heavy rail, rock ballast and the bank widening and ditching work. It is estimated that this saving approximates 500,000 man-hours per year.

If patrolling is eliminated from the man-hours chargeable to grading in 1921, the hours assignable to the other three major operations in the grading group are 1,350,843 or 15.5 per cent of the total track man-hours.

Referring to the statement, it will be noted that the man-hours for current repairs in 1929 were 5,590,042. Applying 15.5 per cent to the 1929 figure results in a figure of 866,457 man-hours comparable to the 1,350,843 man-hours of 1921, or a reduction of 484,386.

The expenditures chargeable to R & E Account No. 3—Grading—shown on Chart No. 5 for a period of 14 years, namely, 1915 to 1929 inclusive, reveal average expenditure per year chargeable to capital account of only $67,900 or about $20 per mile of track per year. This conservative capital expenditure for grading, together with the labor-saving equipment used, seem to be more than justified by the effect in reducing man-hours. Furthermore, for the year 1929 the charge to this account was only $19,609 or less than $6 per mile.

For the 10 years, from 1921 to 1930 inclusive, the average expenditure for Account No. 202—Grading—has been $766,865 per year or $223 per mile and for the last four years from 1927 to 1930 inclusive, it has averaged $526,146 per year or $153 per mile of track.

The definite and well-scheduled program which has been followed over a period of years in grading work is now and has been reflecting itself not alone in the account itself, but also in the effect it has on the surfacing, ties, ballast, etc., through the channel of effective drainage.

Summary of Man-Hour Savings in Grading Account

Man-hour savings through reduced patrolling of track............	500,000	M.H.
Man-hour savings through capital expenditures for improved drainage, bank widening and methods of performing this work....	484,386	"
Total man-hour savings—Grading Account............	984,386	"

Reduction in Man-Hours Through Lengthening Maintenance Sections and Use of Specialized Gangs

As stated previously, there was a reduction of 26 per cent in the number of maintenance sections during 1928 and 1929 as compared with 1927.

To a large extent, this reduction was brought about by the lessening of the work normally assigned to the sections and allocating it to specialized extra crews. We further find by referring to Chart No. 2 that this was done without any perceptible increase in extra crew hours.

The section laborer hours in 1927 on the Lehigh Valley were 4,805,592 and the section foremen hours 970,770, or a total of 5,776,362. For 1929 the section laborer hours were 3,774,416 and the section foremen hours 743,469 or a total of 4,517,885. The difference in the totals as between the two periods is 1,258,477 man-hours. If we eliminate the man-hours for grading, which have been considered elsewhere and which represent 22 per cent of the total, there remains *981,612* hours that represent a saving assignable to the change in the methods of performing maintenance work by using specialized extra crew forces and reducing section forces to a minimum.

Summary of Assignable Man-Hour Savings (Track Only)

If the following assignable man-hour savings which are listed elsewhere, namely,

Item	*Man-Hour Savings*
Cross-tie treatment	613,612
Reduction in mechanical wear	233,104
Cross-tie distribution	84,672
Use of treated switch ties	57,540
Use of treated bridge ties	32,280
Use of heavy rail	365,610
Reduction in patrolling hours	500,000
Reduction in grading hours exclusive of patrolling	484,386
Reduction through specialized extra crews	981,612
Total	3,352,816

are eliminated from the current repair man-hours of the test period of 9,975,344, there remains 6,622,528 hours. Comparing these with the 5,590,042 hours of 1929 shows 1,032,486 hours still unaccounted for. In other words there remains a further reduction in man-hours of 1,032,486 to be explained.

It is not practical, neither is it possible for your Committee to allocate these remaining hours directly to any of the many operations which might bring about the results. It would seem sufficient to state a few of the causes that are responsible.

(1) Since 1925 a 39-ft. rail has been used which has in effect reduced the number of joints in track to be maintained by 16 per cent where this rail is laid.

(2) The man-hours required for the removal of snow and ice have been materially reduced by the use of snow melting devices and improved plows and other machines for handling the material.

(3) The heavy and improved track fixtures have made themselves felt in reducing maintenance man-hours.

(4) Surfacing, lining and gaging of track where laid with 136 lb. rail and heavy plates is reduced to a minimum.

(5) The installing of hard surfaced highway and other grade crossings replacing planking has reduced the hours necessary to maintain them.

(6) The use of ballast deck bridges has reduced the work of the section forces in maintaining the runoffs on either side.

(7) The 10-hour day, during the summer, has the effect of reducing the percentage of non-productive time as compared with an 8-hour day, to the extent of between 2 and 3 per cent of the hours paid for.

The above with other causes which it is possible to mention, will in the Committee's opinion offset the unexplained difference in man-hours.

Equipment Operator's Hours

Investigation of the man-hours for portable equipment operators on the Lehigh Valley shows an increase over a period of years, which in itself indicates the increased use of labor-saving equipment, the effect of which is reflected above.

Man-Hour Saving in Other Crafts

While there has been a reduction in man-hours for carpenters, painters, bridgemen and other crafts, these hours when compared with the reduction in track and extra crew forces are relatively small and have resulted among other things from the use of treated timber, labor-saving equipment, and the capital expenditures for permanent structures.

Referring again to Chart No. 3, it will be noted that there has been a marked drop in the man-hours for signalmen and maintainers on the Lehigh Valley in 1928 and 1929. This was effected by submitting commercial current for bluestone batteries, resulting in a reduction in signal sections from 70 in 1927 to 30 in 1929.

General

In analyzing those operations on the Lehigh Valley Railroad that have reduced the labor required for maintenance of way work, your Committee has attempted to gather all of the information that is available regarding the changes in standards and methods which, to a general extent, were instrumental in effecting the results over a period of years. It is recognized that there are other elements and methods which no doubt have, to an extent, also influenced the results on this railway. It is the feeling that more definite information as to the effect these other recognized operations have in reducing man-hours will be acquired by continuing the analyses on other railways.

Conclusions

To a major extent the marked reduction in man-hours on this railway can be attributed to the following changes in standards or methods of performing work, together with the effect of capital expenditures for Roadway and Structures:

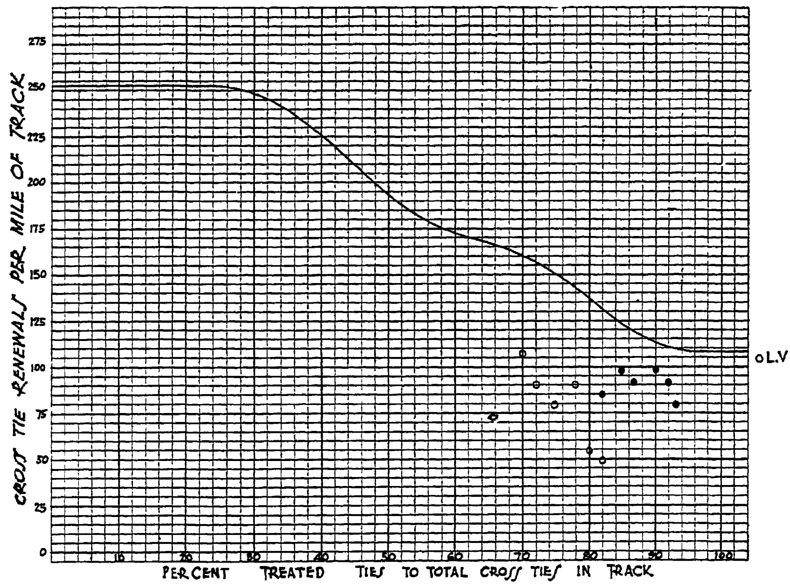
1. Universal use of treated cross, bridge and switch ties.
2. Proper sub-drainage.
3. Roadbed with 14 in. average of rock ballast under ties.
4. Universal use of track motor cars.
5. Lengthening of track and signal sections.
6. Heavy rail (136-lb. rail standard since 1916).
7. Full use of large tie plates (8 in. $\times$ 13½ in.).
8. Out-of-face resurfacing every 3 to 5 years with specialized extra crews.
9. Full use of cranes and other equipment for laying rail and other heavy work.
10. Detouring of trains while relaying rail or when other major maintenance operations are in progress.
11. Laying rail during winter months with available forces.
12. Building up rail ends, frogs, switch points, etc., by welding process.
13. Permanent construction of signs, concrete culverts and bridge slabs, rail rests and other units and structures.
14. Use of treated timber in wooden bridge construction.
15. Full use of mechanical tamping machines.
16. Use of cranes in batteries for cleaning ballast, ditching and other operations.
17. Discontinuation of spacing joint ties to fit spike slots.
18. Use of commercial current for signals, replacing batteries.
19. Systematic methods and care in scheduling of maintenance work.
20. Use of snow melting devices and improved snow removing equipment.
21. Ten-hour day between April and October, thereby reducing the percentage of non-productive time.
22. Ample supervision and inspection of all work.
23. The spirit of the organization.

Recommendation

The Committee recommends that the report be received as information and the subject continued.

CHART #1

RELATION OF CROSS TIE RENEWALS PER MILE OF TRACK
TO PERCENT OF TREATED TIES IN TRACK.



NOTE: The above Chart developed from Am. Wood Pres. Assn. Records covering 204,246 Miles of track.

· LEHIGH · VALLEY · RAILROAD ·
TOTAL MAN-HOURS-SECTION AND EXTRA-CREW LABOR, AND MAN HOURS PER MILE OF TRACK.

CHART #2

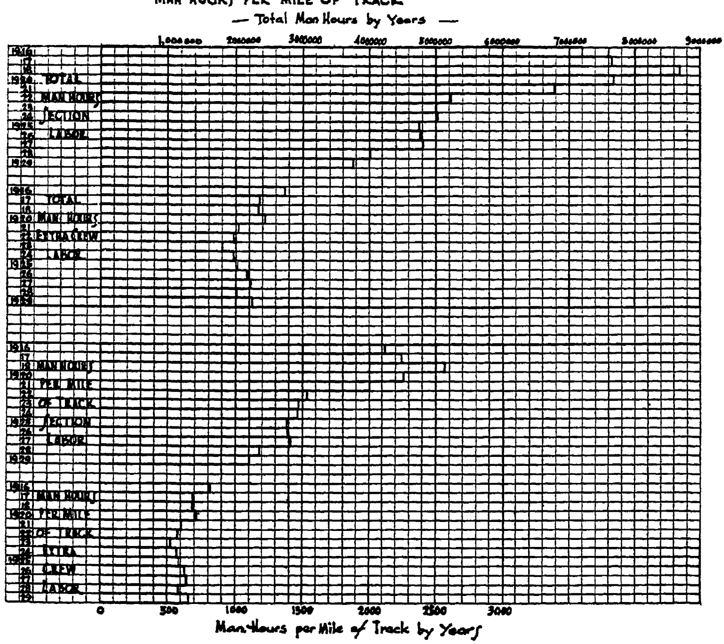


CHART #3

LEHIGH · VALLEY · RAILROAD ·

TOTAL MAN HOURS BY YEARS-SECTION FOREMEN-SIGNALMEN & MAINTAINERS

1921 TO 1929 INCLUSIVE

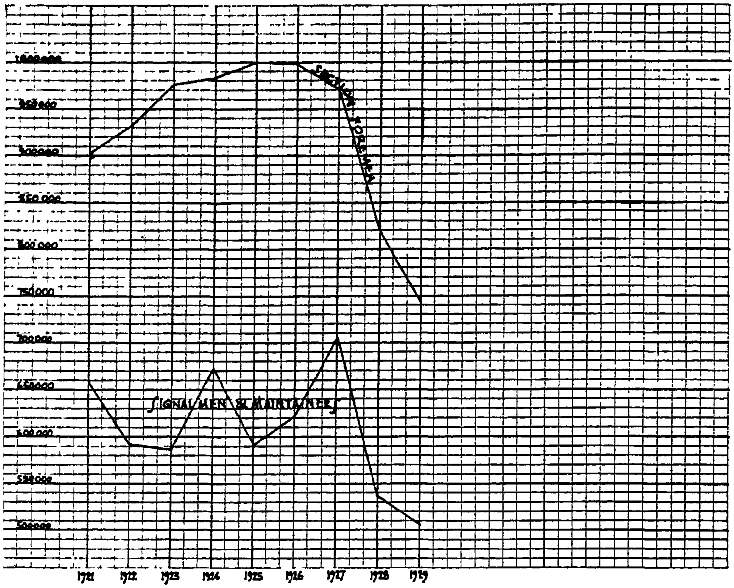
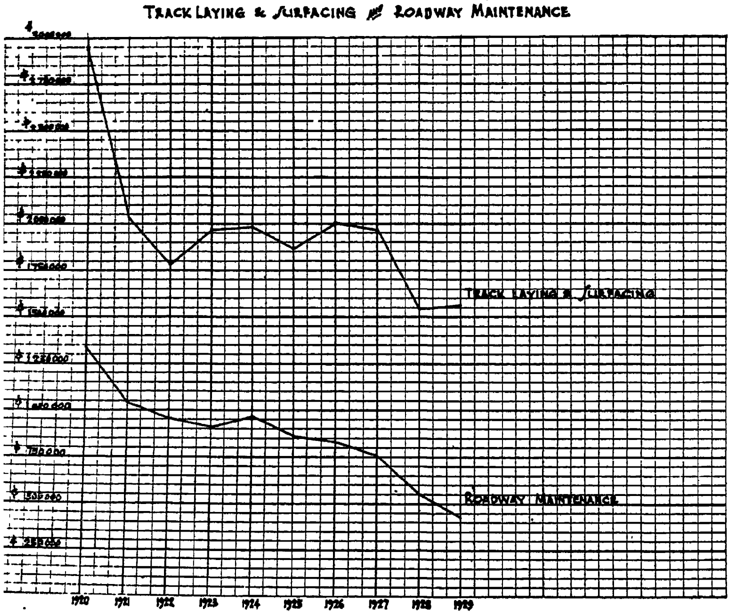


CHART #4

· LEHIGH · VALLEY · RAILROAD ·

MAINTENANCE EXPENSE BY YEARS.

TRACK LAYING & SURFACING & ROADWAY MAINTENANCE

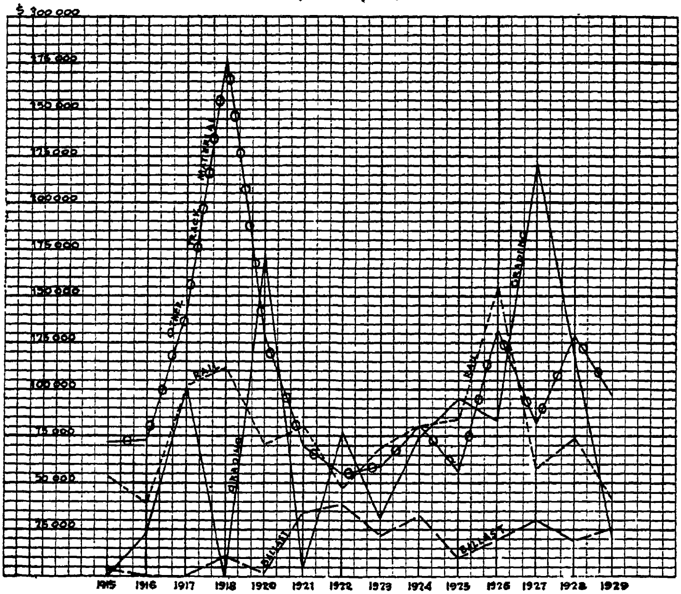


• LEHIGH • VALLEY • RAILROAD •

ADDED CAPITAL INVESTMENT BY YEARS

FOR O·T·M·, RAIL, BALLAST AND GRADING

CHART #5



• LEHIGH • VALLEY • RAILROAD •

M. of W. AND STRUCTURE EXPENSE & COST PER MILE OF TRACK

1920 TO 1929 INCLUSIVE.

CHART #6

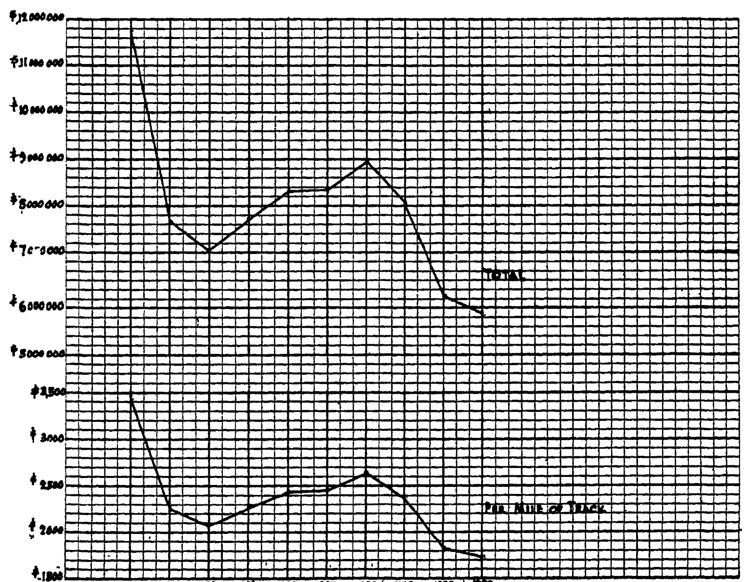


CHART 17

· LEHIGH · VALLEY · RAILROAD ·
ADDED CAPITAL INVESTMENT BY YEARS
FOR BRIDGES, SIGNALS & ROADWAY MACHINES.

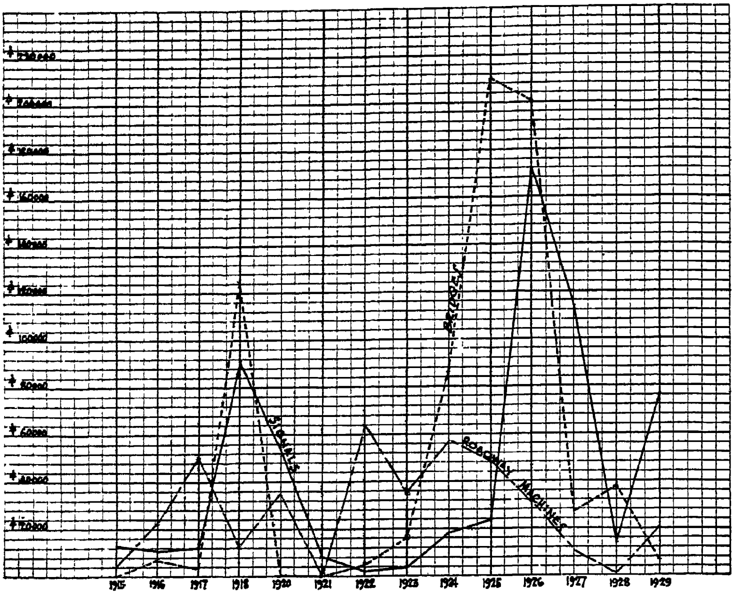


CHART 18

· LEHIGH · VALLEY · RAILROAD ·

COST PER TRACK MILE FOR TRACK ITEMS & M. OF W. RATIO TO OPERATING REVENUES

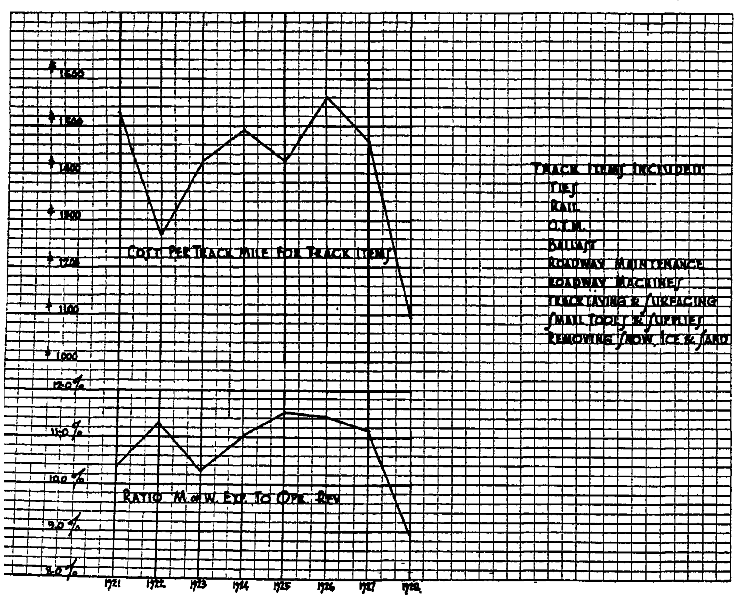
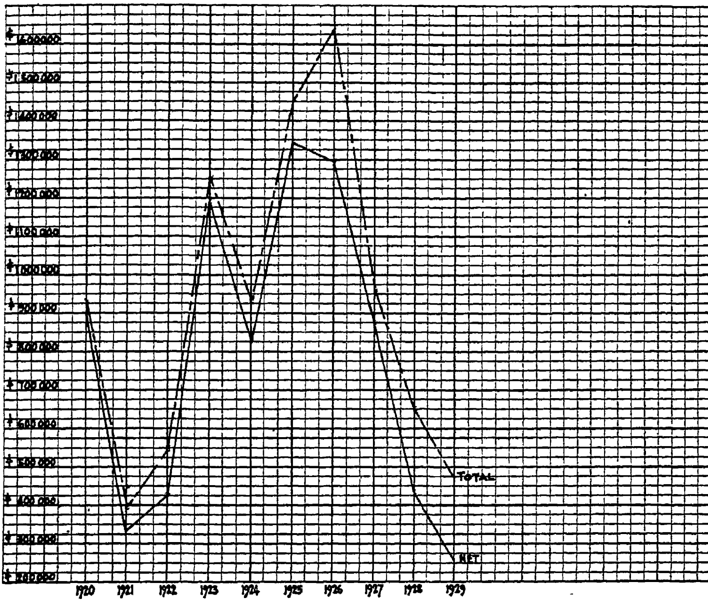


CHART #9

· LEHIGH · VALLEY · RAILROAD ·
ADDED INVESTMENT BY YEARS M. OF W. ACCOUNTS
1920 TO 1929 INCLUSIVE.



Appendix C

(3) EFFECTS OF RECENT DEVELOPMENTS IN MAINTENANCE OF WAY PRACTICES OF GANG ORGANIZATION (SUCH AS USE OF HEAVIER RAIL, TREATED TIES, AND LABOR-SAVING DEVICES, WHICH MAKE PRACTICABLE SMALL SECTION FORCES, AND CONDUCTING THE MAJOR PART OF MAINTENANCE WORK WITH EXTRA GANGS)

F. S. Schwinn, Chairman, Sub-Committee; G. A. W. Bell, Jr., W. R. Bennett, A. E. Botts, J. F. Dobson, John Evans, H. I. Hoag, J. H. Kelly, J. A. Parant, Wm. Shea.

In the report of this Committee under Appendix A as printed on pages 194 to 197, inclusive, in Vol. 32, Proceedings, there is given the definite conclusion that recent developments in maintenance of way practices have reduced the amount of track labor required for adequate maintenance. It was further concluded that such developments should permit transferring of additional heavy routine maintenance work formerly performed by section gangs to specialized gangs properly equipped, with large attending economies.

The natural desire, as well as the economic requirement of the present day, is to provide adequate and safe track maintenance at the lowest possible cost. Many factors have contributed and are continuing to contribute their effects toward the realization of economies in this field of railway operation. Some of the more important factors include heavier rails, improved joints, better ballast sections, treated ties and the general use of tie plates. All of these and many other items of physical improvement have

reflected their benefits in the reduced amount of maintenance labor required for any given measure of use.

In addition, marked economies have been accomplished through the use of labor-saving equipment and devices which have been developed during recent years. Many of these are now in use in track and roadway work. A list of the more important would include equipment such as ditchers, spreaders, cranes and hoists of both locomotive and crawler types, motor trucks and track motor cars, and such devices as tie tampers, ballast cleaners and discers, track mowers and burners, rail laying machines, tie adzing machines, spike drivers and pullers, bolt tighteners and joint beveling machines. The use of such equipment and devices has become very general during recent years. Every railway canvassed on the subject reports the regular use of a large variety of machines such as listed.

All of these developments in maintenance of way practices have resulted not only in the direct economies from their use or adoption, but in indirect benefits as well, the latter permitting changes in the organization of track labor. The older and lighter types of track construction required more frequent attention and replacement; manual labor using hand tools was formerly the rule. The result was that large section gangs had to be assigned to comparatively limited mileage. These gangs had to perform all kinds of track work, and not infrequently they had to undertake several different kinds of work in the same day.

With the advent of more improved practices, the formation of extra gangs for rail laying, ballasting, and, in some instances, for heavy tie renewals, became the recognized standard. But further developments have brought about additional changes. Much of the so-called ordinary track maintenance can be more economically handled by specialized maintenance gangs. The foremen and laborers, usually recruited from the section gangs, can be specially trained for their particular duties. Such gangs are fully equipped with modern labor-saving machines and each man performs the same operation daily with naturally resulting efficiency. Reasonably large gangs for such work are required in order to warrant their full equipment with labor-saving devices and the necessity of keeping these machines in as nearly continual use as possible, as well as to reduce the amount of time required in closing up work and restoring track to normal, thereby reducing the interference with train operations.

These specialized maintenance gangs, where used, have permitted increasing the length and decreasing the number of sections and the reduction of labor in the remaining sections to the minimum required for patrolling purposes and such emergency work as needs attention before the maintenance gang could reach the section. A number of railways have organized their track maintenance forces along these lines and there is a growing interest and tendency in this direction among many others. A special study has been made of practices now in effect on several selected railways, a resume of which follows:

Chicago, Milwaukee, St. Paul & Pacific

This railway commenced its experiments with large maintenance gangs in 1929 when one gang was organized and put to work on the La Crosse Division. The laborers and supervisor for this gang were taken from the section allowance for that division and it was regularly engaged from April to September, inclusive. The average organization included a general foreman, 2 foremen, 2 assistant foremen, 3 machine operators and 86 laborers. During a period of six months, this gang completely rehabilitated about 65 miles of track, including the renewal of about 700 ties per mile, complete resurfacing and final finishing and dressing of ballast and track ditches. The special equipment included track jacking, tie tamping and ballast dressing machines, and the cost of performing this class of work in 1929 was reduced very nearly 20 per cent as compared with costs of two years previous.

The results of this test were so satisfactory that six similarly organized gangs were employed in 1930 and in 1931 the number was increased to eleven, eight gangs being assigned to main track territories and three to the larger terminals. These gangs include an average of about 75 laborers each with plenty of supervision and each gang is equipped with an eight-tool tie tamping outfit, a power track jack and a ballast dressing machine. The full season's work for each gang is planned in detail before the gang is organized and this work is then programmed throughout the season. Charts showing weekly progress as compared with the program are kept up to date and it is noticeable that these gangs are generally up with or ahead of their programs. In each case the labor assigned to the maintenance gang is taken from the regular track labor allowance for the territory on which it is working.

This railway also handles all rail laying with system gangs. These gangs have from 170 to 175 laborers and are fully equipped with power-operated spike pullers, adzing machines, rail laying machine, bolt tightener and track drill. One of these gangs will average approximately two track miles of rail relayed per day. As a result of systematic programming, using laborers who have become skilled in their own particular work and the necessary labor-saving equipment, the cost per mile of track relayed has been reduced about 40 per cent as compared with costs five years ago.

In the early part of this season (1931) a system ballasting gang of 275 men was organized. Adequate supervision is provided, this gang having a general foreman, four gang foremen and eight assistant foremen. One machine supervisor, four machine operators, two timekeepers and a material clerk are also assigned to this gang. This gang has been following a system rail laying gang, making a four-inch raise on gravel ballast including all incidental work such as skeletonizing, tie renewals, unloading gravel and ties, dressing ballast to standard and cleaning up scrap, burning old ties, etc. Ballast was delivered at the rate of about 80 cars daily in regularly assigned gravel trains and was unloaded after 5:00 p. m. With this program and organization, interruption of traffic was minimized. The gang averaged 8½ miles of completed ballasting per week at a total labor cost of $735.00 per mile as compared with a cost of $1750.00 per mile four or five years ago when similar work was performed by division gangs consisting of about 75 men each. This reduction in cost of ballasting is approximately 58 per cent.

The Pennsylvania Railroad

While this railway has not attempted any general reorganization of its maintenance of way forces, the heavier maintenance is now performed by gangs of sufficient size to operate mechanical equipment and properly perform the work and this practice has permitted a reduction in the number of sections with a corresponding increase in length and a considerable decrease in the amount of labor assigned to the sections for ordinary maintenance. The plan followed is briefly: (a) organize special gangs in camp trains for rail laying; (b) provide special gangs for raising track, spacing ties and tamping where considerable stretches of such work are to be performed, and (c) adjust section forces in accordance with the amounts of work remaining to be done on the sections. The results of this policy have been reflected in a 40 per cent reduction in cost of rail laying and a 33 per cent reduction in the present annual cost of track laying and surfacing and roadway maintenance as compared with four years ago, and a better general maintenance condition due to the fact that section forces were relieved of heavy repair work and were better able to attend to the maintenance of those portions of the track not requiring heavy repairs.

The special gangs are furnished to a large extent with power machines and tools, the use of which requires experienced labor for effective results. They are assigned to such territories where a large amount of continuous work is required on one or more sections. This does not relieve the section forces of their responsibility of maintenance and they may be required to do heavy work as in the past if the program of the special gangs is not extensive enough to cover all of the heavy work. In such cases the force is adjusted to meet the conditions.

Reports from the Central Region indicate that 86 per cent of the rail renewal work is performed by two rail laying gangs averaging 90 men each, including foremen. Each gang is equipped with four to six power-operated track wrenches, four adzing machines, two grinders for sharpening adzing machine bits, a rail laying crane supplemented with a power-operated rail layer for emergency use, four to six power-operated spike drivers, two spike pullers, a joint beveling machine, two bonding machines and such motor cars,

trailers and trucks as are required by a gang of this size. Each rail laying gang is supplemented by local forces making up a 17-man distributing gang and a 20-man picking-up gang equipped with necessary cranes and magnet for handling material.

Other heavy maintenance activities handled by special gangs on the Central Region include about 95 per cent of all ballast cleaning which is performed with moles; all heavy ditching which is done by batteries of cranes, the bank shaping being done by spreaders, and tie renewals which are handled on heavy traffic lines by special gangs of from 20 to 40 men each, the practice being to raise the track and renew the ties in advance of the tamping units. All work is carefully programmed within the working season limits, schedules being based on the normal output of a gang on any given class of work.

During the past four years the Central Region has made a 7 per cent reduction in the number of sections and has increased the length of sections by 21 per cent. In the same period the total labor worked in section and extra gangs per mile of track has been decreased 44 per cent. While some of the decrease in labor was attributable to decreased traffic, nevertheless a considerable portion of the labor-savings reflects the results of what might be termed mass production activities.

Great Northern Railway

This railway commenced its studies of revised organization for the handling of section work in 1927 and the plan then developed has proven so satisfactory that it has since been made effective over the entire system. Briefly, the plan contemplates a floating maintenance gang for each Roadmaster's district. In some instances two such gangs are provided for one district. These gangs include from 15 to 25 men each and are employed only through the working or summer season.

During the off or winter season the section forces are reduced to the minimum required for patrolling, removal of snow, etc., usually a foreman and one laborer being sufficient. The difference between this force and the normal section force represents a considerable labor-saving and this is available for use in organizing the district maintenance gangs. During the working season, normal section forces amounting to from five to seven men on main line sections averaging 10 miles in length, three to five men on secondary lines with sections averaging 12 miles in length and two to three men on the branch line sections varying from 13 to 15 miles in length are engaged on all usual section work including renewing ties, lining, surfacing, etc., except such stretches of track which have been previously designated for attention by the district maintenance gangs.

The work of the district maintenance gangs is programmed a year in advance. The sections overhauled are thoroughly retied and resurfaced by them, applying such additional ballast as may be required. During the year previous to such overhauling the tie renewals by section gangs are restricted as much as possible so the major renewals are made by the district maintenance gangs. This railway has made no change in its past practices with respect to extra gang work. Extra gangs are used for all heavy rail relaying projects, tie plating, ballasting and similar work.

The plan of organization in effect on this railway has permitted a reduction of 26 per cent in the number of sections and a saving of about 23 per cent in the cost of ordinary section maintenance. One-fifth of the total saving is attributed to labor-saving equipment and the balance is directly caused by the change in organization. It has been found that these district maintenance gangs are not interrupted by various minor duties as is the case with section gangs, and are therefore able to accomplish more work in a given time. This has permitted the maintenance officers to undertake and complete a definite plan of overhauling each year.

Boston & Maine Railroad

This railway has recently made some very decided changes in its organization for track maintenance with satisfactory resulting economies. On heavy traffic main lines with good rail and ballast conditions, large maintenance gangs of approximately 70 men are used for complete out-of-face rehabilitation consisting of resurfacing, renewal and respacing of ties, gaging and lining, trimming of ballast and sub-shoulders and other general work. These gangs are made up of experienced and specialized foremen and laborers and their work is scheduled and controlled. The rehabilitation is done to the extent which will put the track in shape to withstand the traffic demands for a period

of four or five years with greatly reduced maintenance labor. After a section has been gone over in this manner, the section forces are reduced to the minimum required for patrolling, spot surfacing, bolting and other minor duties, and the savings so effected represent large returns on the cost of the rehabilitation work.

This railway has not attempted any change in the method of maintaining heavy traffic lines where rail is light and ballast conditions are not good. On its light traffic branch lines the territory previously comprising several sections has been consolidated and is covered at sometime during the period from April to October, inclusive, by a floating maintenance gang consisting of approximately twenty men. The track is completely retied and spot surfaced. After the territory has been covered by this gang, the ordinary maintenance consisting of patrolling, bolt tightening and other minor work is handled by a foreman and one laborer excepting that the gang is increased by two laborers during winter months to handle shimming, cleaning snow from switches and similar work. In the first test of this method, made in 1930, labor costs for the year were reduced nearly 38 per cent, and the results have been so satisfactory that the method has been adopted for a number of other light traffic branches with equally good results and economies.

While the railway's report principally covers its practice with respect to track maintenance aside from large ballasting and rail laying projects, it handles such large projects with large specialized gangs fully equipped with labor-saving devices and machines and utilizing traffic diversion whenever possible.

Missouri Pacific Lines in Texas and Louisiana

These lines have effected noticeable track labor economies during recent years as the result of operating ballast discers, weed mowers and burners, rail oilers, and through the use of floating maintenance gangs. These gangs, when fully recruited, average 20 or 25 men each and one or two gangs are assigned to each Roadmaster's district. The labor allowance for such gangs is taken from the ordinary section allowances, these forces being reduced to compensate for the floating gangs. The work of these gangs consists principally of out-of-face retieing and reballasting with necessary regaging, resurfacing and lining.

Throughout the greater portion of the territory covered by these lines the growth of vegetation is very rank during about nine months of each year. The hand removal and cutting of vegetation from the ballast and side slopes of the embankments has been entirely eliminated by the use of ballast discers, mowers and burners and this has permitted very large savings in labor.

For many years the standard practice on these lines has been to handle all heavy reballasting and rail renewals with extra gangs and there has been no change in this respect. During the past season, track maintenance on a number of the less important branches has been entirely turned over to floating gangs which are given regularly assigned territories of from 35 to 50 miles. In such cases all section gangs have been discontinued and the maintenance responsibility placed with the floating gang foreman. The changes in methods and practices referred to have permitted a reduction of 21 per cent in the number of sections and an increase of 29 per cent in the length of sections during the past three years. At the same time, ordinary labor required for track and roadway maintenance and including labor in floating maintenance gangs has been reduced 33 per cent.

Conclusions

(1) Recent developments in maintenance of way practices such as the use of improved materials and labor-saving devices have reduced the amount of track labor required for adequate maintenance.

(2) These developments in maintenance of way practices permit transferring the heavier routine maintenance work from section gangs to specialized gangs equipped with modern labor-saving machinery with large resulting economies.

Recommendations

The Committee recommends that this report be received as information; that the conclusions be adopted for printing in the Manual; and that the study of this subject be continued.

Appendix D

(4) ANNUAL TRACK INSPECTION AND PRIZE AWARDS

E. T. Howson, Chairman, Sub-Committee; H. A. Cassil, J. F. Dobson, C. H. R. Howe, C. H. Paris, J. C. Patterson.

For many years certain railways, and more recently a number of others, have made annual inspections of their tracks and roadway, partly for the purpose of determining the relative efficiency of the various forces engaged in maintenance work and partly to stimulate friendly rivalry among these forces by making the results of the inspections competitive. While the purpose is fundamentally the same in all of the cases which have come under the observation of the Committee, the methods of making the inspections and of utilizing the reports vary widely on the different roads which follow the practice.

In making a study of its assignment, the Committee finds that numerous other roads do not now and have not heretofore made inspections of this character. It also finds a decided difference of opinion on the part of the engineering officers of these roads as to the desirability of doing so. Some of them, admitting that they do not speak from experience, are of the opinion that the cost of such an inspection can not be justified and that the effort employed in making it will be wasted. Other officers favor the practice because they believe that it results in definite advantages to the maintenance forces and in benefit to the property. Several of the latter do not advocate it for their roads however, because of financial reasons or because the maintenance practices on different parts of their systems are not yet sufficiently standardized.

Between these two classes is a third, which includes a relatively few roads that formerly made annual maintenance inspections, but which have discontinued the practice for various reasons. In a few cases this was done because of financial considerations; in others because it was believed that the benefits were insufficient to warrant the expense. One road did so with the thought that the same purpose could be accomplished by requiring more frequent inspections at approximately regular intervals, by division, district and general officers. One road discontinued the practice during Federal control and has not resumed it since, on the ground that it is fundamentally unsound. This road takes the position that the attainment of uniform efficiency in the performance of maintenance work is a matter of intelligent supervision, and that it is unwise to offer "prizes to employees for properly looking after routine work which is assigned to them, and for which they receive due compensation."

A study of the methods employed by those roads that have been making annual maintenance inspections for a sufficient time to develop a settled practice, indicates that while the objective sought—a friendly rivalry between the various units of the maintenance organization and a determination of the relative efficiency of these units—is the same in all cases, the manner of conducting the inspections and of arriving at the final result varies between rather wide limits. A few outstanding examples will illustrate.

Canadian Pacific

On the Canadian Pacific, at about the close of the season's work, each Roadmaster selects the particular section on his subdivision on which in his opinion the most efficient work has been done during the year. This selection is based on the general improvement made during the year and is not necessarily the section that has the best track.

This choice is reported to the Division Engineer and Superintendent. These officers, in company with the respective Roadmasters, then inspect the selected sections on all of the sub-divisions and choose the prize section for the division, making a report to the General Superintendent. The General Superintendent and District Engineer, accompanied by the Superintendents and Division Engineers of the respective divisions, make a similar inspection and first and second choices for the grand division, and report to the General Manager and Engineer Maintenance of Way. These latter officers, accompanied by the respective grand division officers, then make their inspection. As soon as the General Manager and Engineer Maintenance of Way have agreed as to the prize section, the list is made up to include all of the sections thus selected.

Prizes are awarded as follows: The General Manager's prize of $100 goes to the best sections on Eastern and Western lines. The General Superintendent's prize of $50 is given for the best section on the grand division, while prizes of $25 and $10 are allotted for each division and sub-division respectively.

All of the officers taking part in the inspection walk over each of the sections they inspect. No specific task is assigned to any officer, each one being expected to make such notes as will enable him to make a fair and intelligent decision after a general comparison and discussion of the features observed. Merely as a guide, however, each member of the inspection party carries a list to indicate the weight that should be given to the several features of the work. This list is as follows:

Ditching, 15; gage, 10; spiking, 10; line, 20; surface, 20; bolts and rails, 10; switches and sidings, 5; right-of-way, 5; track signs, stock guards and fences, 5. A system of handicaps is used to equalize the physical conditions on sections, to allow for tie renewals, the amount of ditching, the amount of snow fence, the shimming that is required, and other features over which the foreman has no control.

Central Railroad of New Jersey

On the Central of New Jersey the inspection is made by means of a special train which carries the Assistant to the President, in charge of maintenance, the General Manager, the Chief Engineer and all subordinate maintenance officers to and including assistant supervisors. Superintendents accompany the train over their respective divisions. The inspection is made by the supervisors and assistant supervisors of track, each of whom judges and records conditions on all subdivisions except his own. The features given consideration and the weight attached to each are line, 35; surface, 40; and general conditions, 25.

Prizes are awarded according to the final rating: The best main-line section on each supervisor's district receives $50, while $25 goes to the second best. Similar prizes are given for the best and second best branch-line sections on each supervisor's district. An improvement prize of $25 is also awarded on each division to the section showing the greatest improvement over its rating for the previous year. No allowance is applied for the purpose of equating those sections that have received help from extra gangs.

Delaware, Lackawanna & Western

A similar inspection is made on the Delaware, Lackawanna & Western, by a committee appointed by the Principal Assistant Engineer, comprised usually of maintenance officers from other roads. Each member of the committee marks the individual items as he observes them, using the following factors for weighting the ratings: Surface, 40; line, 35; and general conditions, 25.

After the markings for any section are completed, the record of the section for a period of seven years is checked. The maintenance on this road is on an equated mileage basis, and a fixed number of man-hours is allowed for each equated mile. If this allowance has been exceeded during the year on any section, and the average expenditure per equated mile for the current year together with that for the six years preceding is greater than the fixed allowance, this section is eliminated from consideration for the prize. Prizes of $100 and $50 are awarded to the respective sections receiving the highest and second highest ratings on each division.

A foreman who receives the first prize for three consecutive years is placed in the "Efficiency" class and receives a bonus of $10 a month so long as he continues to maintain his section to a high standard. In addition to the cash prizes, first and second-prize medals are given to the winners in the competition, while a large sign reading FIRST PRIZE is placed at the tool house on the section receiving the first prize, and similar signs bearing the letter "E" are placed on all sections in the efficiency class.

Norfolk & Western

For many years the Norfolk & Western has conducted annual track inspections, which include all main line mileage and the most important branch lines. The inspection begins about October 10 and requires approximately two weeks to complete. The special train used for this purpose consists usually of two observation inspection cars, one day coach, one sleeping car and one business car. One of the inspection cars is placed ahead of the locomotive and the other at the rear of the train. Roadmasters, Assistant Superintendents, Superintendents and other officers occupy the inspection car at the front of the train, while the rear car is occupied by the section foreman from the division over which the train is being operated.

In making the inspection, the Roadmasters from each of the grand divisions are assigned to committees, it being practicable generally to assign several Roadmasters to each committee. All of them, except the Roadmaster whose district is under inspection, observe and rate the items assigned to them. The section foremen from the division on which the inspection is being made accompany the train over that division. They are organized in exactly the same way as the Roadmasters and also observe and grade the sections over which they pass.

Special blanks are provided for recording the ratings, one being furnished to each of the members of the inspection committees. After the inspection is completed on any division, the Superintendent, using all of the records turned in, determines the general average of each of the sections, the general average for each Roadmaster's district and that for the division. The weighted value for each of the items covered by the inspection are: Line and surface, 3; switches, frogs and road crossings, 2; ditches and roadbed, 2; right-of-way, 1; station grounds, 1; and fences, if any, 1. It is considered that perfect conditions of track and policing are impossible of practical attainment, so that no markings in excess of 9.5 are permitted.

Four prizes are awarded for each Roadmaster's district. The first prize is $40, the second is $30, the third $20 and the fourth $10. In addition, a number of the Roadmasters on this road voluntarily give similar prizes at their own expense in order to maintain the rivalry among their foremen, generally for maintaining the most pleasing grounds around the section dwellings.

Pere Marquette Conducts Broader Inspection

Three items in addition to track and right-of-way, are included in the annual inspection which has been in effect for 30 years on the Pere Marquette, and which inspection is made during October of every year. In addition to the Chief Operating Officer, the Chief Engineer and the maintenance staff, the inspection party includes the operating officers, the Superintendent of Motive Power, the Engineer of Bridges and Structures, the Signal Engineer and Superintendent of Telegraph, and one or two section foremen from each supervisor's district. Master mechanics accompany the party over their own territories.

Seven committees are formed to observe and rate the several items that are considered in making the inspection. These items and the weighting of each are: Line and surface, 3; roadbed and drainage, 1; ballast section and dressing, 2; policing of right-of-way and station grounds, 1; fences, crossings and signs, 1. Committee 6, signals and interlockings, does not accompany the inspection train, but makes its inspection at a different time, using a track motor car for this purpose. Similarly, Committee 7, shops, shop grounds, repair tracks and enginehouses, makes a separate inspection.

Cash prizes are given as follows: $100 to the supervisor having the highest rating; $100 to the supervisor showing the greatest improvement; $25 for the best section on each supervisor's district; $25 to the section foreman on each supervisor's district who has made the greatest improvement as compared with the previous year; $25 to the best section on each superintendent's branch lines and $25 to the branch line section showing the greatest improvement; $50 to the signal supervisor receiving the highest

grade on the condition of his interlockings and automatic signals; $100 to the master mechanic who is rated highest on the condition of his shops and the general efficiency of his operations. A prize of $25 is also awarded to the agent on each division who has shown the greatest general efficiency in the conduct of business and in the care of the station buildings.

Similar inspections, which are confined to the track and right-of-way are made on the New York Central, the Baltimore & Ohio and the Lehigh Valley. The first two of these roads award cash prizes, while the Lehigh Valley gives no special recognition to the winners, except to send the results of the inspection to everyone who participates in the competition.

St. Louis Southwestern

It is the practice of the St. Louis Southwestern to make an annual maintenance inspection of tracks and structures to determine the relative efficiency of its forces and to give special recognition to those who have made the best records in this respect. These inspections are made by committees, and their records are turned over to a general committee which modifies them in accordance with certain predetermined rules. In evaluating the items which are included in the inspection, the following weights are used: Line, 30; surface, 35; gage, 20; neatness and drainage, 10; tool houses and station grounds, 5. The gage is determined in advance of the inspection by means of a motor car with a Barceloux gage attached, and the markings for this item are determined by the general committee.

To modify the primary ratings equitably, the sections are considered on an equated mileage basis and the number of man-hours employed per equated mile is compared with the average for the system for the current year. Since maintenance expenses are affected directly by the amount of traffic, however, this system average of the man-hour allowance, for the purpose of making the comparison, is increased or decreased in accordance with the following factor:

$$(1 \pm 0.365\,T)M$$

in which T is the ratio of traffic density on the section to the average traffic density for the system; M is the average number of man-hours on the equated mileage basis; and the constant, 0.365, is the percentage of maintenance of way labor accounts that are affected by use.

The original rating of the section is then adjusted on the basis of ½ of the percentage of excess or deficiency in the number of man-hours actually employed, as compared with the computed allotment.

Erie

A combination of two methods of inspection is in effect on the Erie. A track inspection car is employed, which registers high and low joints, cross level and gage, and the ratings for these is determined by a committee of two from the charts made by the recording instruments in this car. The ratings for line, ditching, policing and other items not obtainable with the car are determined from observation by a committee of two made up from the personnel of the inspection party, which includes the Chief Engineer Maintenance of Way, the Engineers Maintenance of Way, the General Roadmasters, the Division Engineers, the Assistant Division Engineers and the track supervisors.

The ratings for tool houses are computed from an inspection made by the division engineers in advance of the track inspection. After the preliminary ratings are computed, they are modified by adding or deducting a factor which is $\frac{1}{10}$ of the percentage which the actual number of man-hours employed is below or above the standard previously determined for the equated mileage of the section under consideration. In awarding the prizes, this road eliminates from consideration any section upon which the number of low joints equals or exceeds the number of miles on the section, if it is a main-line section, or twice the number of miles if it is on a branch line. A supervisor does not participate in the distribution of prizes if the total number of low joints on his district exceeds one-half the miles of main track, if on a main line, or if it equals the number of miles on a branch line.

Prizes are awarded to track supervisors and section foremen. The supervisors prizes include $200 for the highest rating and $100 for the next best main line sub-division on each district, while the best branch line sub-division on each district also receives $100. A banner prize of $150 is given to the best section on each district and first and second division prizes are awarded in the respective amounts of $100 and $50.

Pennsylvania

Periodical inspections are made by the Pennsylvania at intervals of six to eight weeks throughout the year, in which a track-recording instrument is employed to indicate the variations in the line and surface of the track. In addition, the Hallade track-recording instrument is also used to obtain a graphical representation of the track variations. In some instances a special train is used, while in others a business car is attached to a regular train. This inspection is conducted by a committee of four from the maintenance of way department, who are appointed by the General Manager, which committee determines the relative standing of the supervisor's subdivisions and of the track foremen's sections. In addition, separate annual inspections are conducted on each region of the system, to determine the relative standings for the distribution of the track awards.

Each member of the committee grades all of the features which are given consideration, including line, surface, ballast, drainage conditions, tie spacing, etc. The ratings for line and surface are based on the record made by the instrument readings. Other features are rated in accordance with the judgment of the individual members of the committee.

In recognition of the competitive efforts made by the participants, cash prizes are awarded on each region as follows:

A grand, or Klondike, prize of $1200, of which $800 goes to the supervisor and $400 to the assistant supervisor.

Nine division prizes of $650, of which $500 goes to the supervisor and $150 to the assistant supervisor.

Fifty-four prizes of $100 each to main-line foremen.

Twenty-one prizes of $150 each to branch-line supervisors.

One hundred thirteen prizes of $50 each to branch-line foremen.

Chesapeake & Ohio

The general plan on the Chesapeake & Ohio is to make an inspection during the last week of October or the first week in November of every year, which includes all main lines and the principal branches. An inspection car equipped with automatic recording instruments, makes a graphic record of low joints and cross level. A referee, who is a member of the staff of the Engineer Maintenance of Way, and a committee consisting of two division engineers grade the sections for general maintenance, appearance and other qualities not subject to mechanical inspection. In the final computation, the machine records are given a value of 60 and the ratings made from observation a value of 40.

For the purpose of adjusting traffic density difference, the lines are classified in five groups as follows:

Group 1. Double-track main line carrying both freight and passenger service. (Standard as near 100 per cent as possible.)

Group 2. Single and double-track main line over which freight traffic preponderates. (Maximum grade not desired over 95 per cent).

Group 3. Single-track main line carrying passenger traffic principally. (Maximum grade not desired over 95 per cent).

Group 4. Secondary branch lines. (Maximum not desired over 95 per cent).

Group 5. Terminal territories. (As near 100 per cent terminal standard as possible).

Prizes of $50, $40 and $30 are awarded to the supervisors in groups 1 and 2 who receive respectively the first, second and third highest ratings in these two groups. A prize of $50 is also given for groups 1 and 2, to the supervisor whose territory shows evidence of the greatest improvement, as compared with the preceding year. A similar prize is given for groups 3, 4 and 5. First and second prizes of $50 and $40 are awarded to the best and second best subdivisions in groups 3, 4 and 5. A first prize of $25 and a second prize of $15 are awarded to the section foreman on each supervisor's territory who receives the highest and second highest rating.

This annual track inspection is made to serve two purposes: (1) The selection of districts and sections of outstanding maintenance merit, and the awarding prizes in recognition of achievement and (2) through the compilation of the records of the inspections and the comparison of the ratings in percentage terms, based on established standards, the condition of each district, section and mile is readily seen and the improvement, or decline, noted from year to year.

In 1927 there was established on each supervisor's district (Group 1 and 2) a mile of road which was designated a "Standard Mile". The miles thus selected were worked until they conformed as nearly as possible to the railway's standards of track and roadway. These are the goals toward which all foremen are constantly working. The rating of every mile inspected is based on the same theoretical 100 per cent, or "Standard Mile", hence all miles are directly comparable either with each other or with themselves from year to year.

This information is used in the distribution of force and material allotments, both in establishing the annual budget and in applying it throughout the year. Copies of the numerical and graphic records of the inspection of their respective territories are given to the supervisors and foremen for their guidance. The physical condition indicated by the inspection is given consideration, along with the equated mileage when making force allotments.

No attention is paid to the fact that sections at times have the benefit of extra gang labor and heavy renewals with new material. It is felt that the maintenance renewal cycle gives each foreman on the district a periodical opportunity to benefit by such assistance.

Southern Pacific

Annual inspections were conducted on the Texas & Louisiana Lines of the Southern Pacific from 1920 to 1929, inclusive, but this practice was discontinued after the latter year on the ground that the benefits did not justify the expense. It was the practice of this road to grade not only the track, roadbed and right-of-way on both main and branch lines, but also the condition, inside and out, of every section dwelling; of every tool house, pump house and fuel station; of every office building, pumper's dwelling and signal tower; of the bridge and building department's material yards, and of every other facility; as well as of the grounds around all stations.

Every section was graded on the basis of 100, the primary markings being weighted as follows: Alinement, surface and gage, 25; spiking, ties, lining and spacing, switches and frogs, 25; drainage and ballast, 20; policing the right-of-way, 10; section houses and grounds, 10; sidings, 5; road crossings, runoffs and fences, 5. Other buildings and facilities received ratings similar to section houses, although the records for these were kept separate from the remaining track and roadway records.

First, second and third prizes of $100, $75 and $50 were awarded to foremen on every roadmaster's district. Prizes were also awarded to the foreman and the roadmaster having the highest ratings on each grand division. In addition, a cash prize of $100 and a system annual pass were presented to the foreman and his family on each grand division who had the best efficiency record, as determined by his performance during the year, these awards being entirely separate from those based on the markings received during the track inspection.

After the inspection was completed, an itemized report was published in a pocket-sized booklet for general circulation. Illustrations were given of the prize-winning sections and of certain of the prize-winning facilities. The names were published of the maintenance of way and mechanical department foremen who had conducted their work throughout the year without a single reportable casualty to the members of their gangs.

ADVANTAGES AND DISADVANTAGES OF TRACK AWARDS

An effort was made to learn the attitude of the maintenance of way officers on those roads that make annual inspections, with respect to the relative advantages and disadvantages of the competitive features and of giving recognition by the award of prizes in the form of either money, medals or other devices. It was found that while most of these roads award prizes of some character in recognition of the efforts of the participants, a few do not. As some of the latter view the matter, a just award cannot be made, owing to the wide variation in the physical conditions on different sections; to the fact that new rail and new ballast afford a handicap which less favored sections are unable to overcome; to the fact that extra gangs are worked on some sections and not on others; and to the further fact that certain features of maintenance,

such as heavy tie renewals, old and worn rail, drainage, etc., are beyond the control of the foremen.

Opposed to this view, the officers on those roads under study, which make a practice of distributing prizes, as well as some of those on roads which make inspections but do not award such prizes, express the opinion that there is a definite advantage in the competitive feature, since it provides an incentive to do better work and arouses an interest beyond that of simply maintaining their tracks in good condition. A spirit of healthy and friendly rivalry is engendered, which results in neater and better work. While the foremen appreciate the intrinsic value of the awards, they generally give as much consideration to the credit that they receive and to the satisfaction of doing their work a little better than their neighbors.

Observation confirms the opinion that there are definite advantages in setting up a healthy competition in any body of men. It gives them a mutual interest and a common objective to strive for, which are tinged with enough rivalry to stimulate their activities and which cannot fail in this instance to result in benefit to themselves and to the property with which they are connected. It is an important element in the success of such a plan, however, that extreme care be exercised to assure the participants by every means possible that the competition will be fair, that the results will depend on their own efforts and ability and that, so far as practicable, no man will be penalized for conditions over which he has no control.

As a means of giving this assurance, the Committee believes that, at least for the purpose of evaluating the preliminary ratings made during the inspection, all sections should be put on an equated mileage basis; that a standard man-hour allowance should be made for an equated mile; and that the preliminary ratings should be modified to correspond with the excess or deficiency in the number of man-hours actually employed, as compared with this standard. As a further refinement, the Committee suggests the desirability of also giving consideration to traffic density, since this is a material factor in the cost of maintaining track.

Track recording devices, the reliability of which has been tested by long use, are available, which record graphically variations in gage, line, surface and cross level. It has been demonstrated by experience that more consistent grading of the track can be made from the records which these graphic charts provide than is possible from observation. The reasons for this are that the record is continuous, every variation being recorded, while it is to scale, so that minor variations can be distinguished readily from those of greater magnitude. Furthermore, it can be examined without hurry, and the record for any section or sub-division can be compared with any other. Most minor variations and many of greater consequence will escape notice when making observations from the rear of a train that is running from 30 to 60 miles an hour.

It is the belief of the Committee, therefore, that the use of track recording devices of known reliability is desirable, since they eliminate the personal equation from the most important of the items that should be considered and which should be given the greatest weight in any well-devised plan of track inspection. Certain items of maintenance, such as neatness, policing, tie spacing, etc., which should also be given consideration in making the inspection, are not adaptable to mechanical recording. It will be necessary, therefore, that the ratings on these features be made from observations. Since they should be given much less weight, as compared to line, surface, gage and cross level, the personal equation or opinion of the inspectors will have only a minor influence on the final results.

Properly used, track recording machines can be made to have a value far greater than that which is obtained by employing them for annual inspections only. They can

be employed to make inspections at intervals throughout the working season, and the records thus obtained can be used to inform both supervisors and foremen as to the track conditions on their territories and to indicate to them where improvement is needed. If the graphic charts for the sub-divisions are preserved, they will constitute a reliable historical record of the track conditions and of the progressive improvement or retrogression in maintenance.

Experience has demonstrated that some sections may be handicapped by conditions over which the foreman or supervisor has no control, which automatically prevent them from participating in the awards for excellence of track and roadway. In other instances foremen or supervisors who have been transferred to sections or sub-divisions of previous low ratings may through superior ability and application make marked improvements and yet not be able to compete for the prizes that are given for the best track.

If the inspection and distribution of prizes is to be entirely fair, some recognition should be given to the efforts that are made on sections or sub-divisions of this character. The Committee has given much thought to this phase of the matter and is of the opinion that, in addition to the awards made for the best track and roadway, prizes should also be given to the sections and sub-divisions which show the greatest improvement as compared with the ratings for the previous year. In this case, however, in order that the award shall be impartial, the same consideration should be given with respect to the relative traffic density and to the excess or deficiency in the number of man-hours employed.

Conclusions

As a result of its study, the Committee has reached the following conclusions which it recommends for adoption and inclusion in the Manual:

1. Properly directed, competition, stimulated by a material reward for excellence, will increase the interest and activities of the maintenance of way forces.

2. A well-devised plan for an annual inspection with awards, provides a desirable means whereby a definite spirit of rivalry can be aroused and maintained throughout the working season.

3. The participants should be assured that the competition is being conducted fairly and that other competitors are not being afforded advantages which are not also available to them. As a means to this end, the mileage should be equated and a standard man-hour allotment per equated mile should be made. This standard should then be modified to correspond with the traffic density over any section or sub-division. The final ratings should then take into consideration any excess or deficiency in the number of man-hours actually employed, as compared with the standard allotment as modified.

4. The use of track-recording machines to provide comparable records of the variations in line and surface, gage and cross level, is recommended.

5. The records made by these machines have a high value if made at sufficiently frequent intervals and used for the purpose of directing the work of supervisors and foremen, and of indicating to them the points to which they should give preferred attention.

Appendix E

(5) RELATIVE ECONOMIES OF BRUSH VERSUS SPRAY PAINTING

G. M. O'Rourke, Chairman, Sub-Committee; Lem Adams, G. A. W. Bell, Jr., A. E. Botts, J. A. Gorr, C. R. Knowles, G. M. Strachan, Cale Wamsley.

The rapid development of improvements in paint spraying equipment during the last fifteen years, numerous models produced by various manufacturers having appeared on the market, has raised a question concerning the economical line of demarcation between hand and spray painting.

The tendency on the part of railway maintenance and operating officers to defer painting during times of business depression has been very costly. There is no more serious maintenance problem facing the railway to-day. Corrosion is the deadliest enemy of steel structures and any method of reducing the cost of protective painting should be welcomed.

It is generally conceded that spray painting is much less costly than brush work but in many instances it is recommended that spray painting be confined to large unbroken areas, however, on many important bridge jobs no brushes were used after the spray method was introduced and a splendid saving was realized with better results in having the paint adhere more uniformly and getting it into cavities.

The American Railway Bridge and Building Association, after investigating the subject thoroughly, reports that the great advantage of the spray is the rapidity of applying the paint which can be put on two to four times faster than with the brush.

The report warns that "paint thrown on without proper atomization will be laid on too heavily and will need to be brushed out. This is wasteful, inefficient and unnecessary and, with proper equipment, is entirely the fault of the operator.

"Given proper equipment and competent operators, the spray method will do first-class work with little or no additional use of materials and at a very considerable saving in labor."

Replies to a questionnaire submitted to a number of the leading railways of the country were as follows:

"No exact figures on comparative cost of hand and spray painting. No doubt about saving through use of spray.

"Spray painting on large plain surfaces such as girder bridges, water tanks, and various structures where there are not many openings results in a saving of at least fifty per cent compared with the cost of performing such work by hand.

"Labor-saving on surfaces adapted to spray painting runs from 25 per cent to 50 per cent depending on kind and size of surface. Material runs from 5 per cent to 10 per cent more than brush painting.

"Comparison of costs shows as much as 50 per cent saving in favor of paint spray method.

"General average of all structures, there is a saving of 20 per cent in labor and about 2 per cent or 3 per cent in materials.

"A test made by mechanical department in 1927 on cars showed a labor-saving of 32 per cent over brush work and an excess of material consumption of 11 per cent over brush work. At prices for labor and material then current the net saving of spray work over brush work was 26.2 per cent.

"Spray painting requires 20 per cent to 30 per cent less labor but 10 per cent to 15 per cent more paint. Net saving in cost on spray work of 12 per cent to 15 per cent. Spray painting gives a more uniform coating.

"Spray painting varies between ⅓ and ⅔ that of brush painting.

"Costing $6.72 per thousand square feet to paint with sprays as against $12.17 per thousand square feet to paint with brushes. From 40 per cent to 50 per cent of work done with sprays.

"Careful records kept of extensive work done on large terminal showed that cost of labor in spray painting including all structures was one-half that of brush painting. Paint consumed in flat work is about same with spray as by hand except when high wind is blowing when consumption of paint through spray is slightly greater."

Extracts from periodicals are presented below:

A Canadian railway B. & B. Master states that ". . . more economical from a labor standpoint than the brush method, owing to the fact that from five to six times as much surface can be covered in the same time, depending of course, on the nature of the work or the class of structure that is being painted."

A general foreman of painters advises that "The spray painting of steel bridges and other iron and steel structures is one method whereby the cost of the work can be materially reduced and at the same time the amount of effort which is required decreased."

An assistant engineer of buildings writes that "With the proper equipment and properly trained operators, there are no limitations in the use of the spray gun which are not also found in hand painting, while the method provides distinct economies."

Indicative of economies to be obtained through the use of paint spray equipment the following excerpts from articles describing work of unusual magnitude will be of interest:

". . . this road's experience has demonstrated conclusively that a large proportion of its maintenance painting can be carried out more expeditiously and more economically with the intelligent use of its paint spraying equipment than is possible with the brush method, . . . painting of the interior of its new grain elevator which presented a surface of over 3,000,000 square feet to be painted. All of this work was done by the contractor with four two-unit paint spraying machines, and while it was recognized that in doing this work the machines were operating under ideal conditions as regards the character of the surface being painted, the computed results, showing an actual saving in cost of about 50 per cent over that of brush application, and the fact that the work was completed in about one-fifth of the time that would have been required ordinarily, was sufficient evidence to warrant the railway in experimenting with similar equipment in its regular maintenance work with the view of reducing costs and carrying out its programs more expeditiously."

"Spray painting on this road has been done at an actual saving, reports on individual jobs having indicated savings in labor costs ranging from 40 to 50 per cent of the cost of brush painting. At the same time the work has been accomplished in from about one-half to one-fourth of the time. This in turn made it possible both to minimize the size of the painting forces, reducing the annual turnover in the organization, and at the same time to complete the season's work in a more orderly manner."

Work on another large railway is described as follows:

"With this equipment it has been found that the painting of large flat areas can be done most economically, although experience has demonstrated that a large variety of painting work can be accomplished more economically with the paint spray than with the brush, which fact has led to the widespread use of this equipment for both bridge and building work.

"From records kept it is estimated that a saving of approximately 50 per cent is effected in labor, while the work is also expedited materially. It is estimated that the paint consumption runs approximately 10 to 15 per cent more per coat, although this increased use of material is more than offset by the fact that whereas two brush coats

were formerly required in most work to give a satisfactory finish this, in the majority of cases, is now accomplished with one coat applied by the spray method."

Note.—Emphasis is directed to this very important feature of not having to wait for one coat to dry before applying a second coat.

In one practical painting job six men (two operators, two men to strain paint, etc., and two men to move scaffolding) applied sufficient flat interior paint to cover 58,000 square feet of surface in two days. The cost of application, not including the cost of paint, was about $0.0013 per square foot of surface. The use of the spray gun for applying two different types of metal paints has proved very efficient, as will be noted from the results charted below:

Red Lead

	Surface Area Sq Ft.	*Paint Used Gals.*	*Time, One Man—Hours*
Spray machine	2208	6	1.86
Hand brush	2208	7½	16

Red Oxide

	Surface Area Sq. Ft.	*Paint Used Gals.*	*Time, One Man—Minutes*
Spray machine	1170	1¾	16
Hand brush	1170	2½	150

In reply to question concerning the economical dividing line between hand and spray painting two large Eastern roads stated there is no definite dividing line. Two other roads have found that experienced spray machine operators can save money on any class of work.

Five railroads report marked economies through the use of paint spray equipment on all large surfaces of buildings, bridges, water tanks, box cars and fences. Another calls attention to the advantages of spraying rough surfaces like badly pitted steel or old unpainted wood as the paint is blown into small openings.

Seven replied that it is not economical to use spray on small buildings having many openings, cornices, porches, and where more than two colors are applied close together as too much time is lost moving equipment.

Five roads advise against using spray equipment around casings and on trim work where it causes too much cleaning up.

Three carriers do not use spray guns where facing is small on truss bridges because too much paint is wasted in the air.

Two find it uneconomical to attempt spray painting during high winds and in damp and wet weather.

One railroad does not find it economical to spray paint signs, switch targets and stands and another recommends brush painting for wood and metal work on stucco and brick buildings.

It is the opinion of your Committee that as equipment is improved and operators become more skilful in the handling of the guns and shields these objections will be overcome and brush work practically eliminated.

No study of the relative economies of brush versus spray painting would be complete without some reference to programming the work, therefore the important railways of the country were asked if they have a year-around program, to which three replied in the affirmative and eight in the negative.

One railroad programs paint gang work from April to November, another extends the program to December and employs a few painters on inside work during the winter.

One reports that the work is programmed "so far as possible" and does interior work during the winter.

Two prominent railroads have a year-around program for whole-line black paint gangs on steel structures but no program for building work.

It is the opinion of this Committee that greatly increased efficiency with resultant economies may be secured through the organization of system paint gangs working on a well-thought-out program.

The method of transporting men, equipment and materials enters into the economics of this subject. The general custom is to house men in camp cars, and move equipment on flat cars for long distances and on motor cars, hand cars and trailers short distances. Three railroads in congested eastern territory use auto trucks and no doubt this practice will be adopted by other roads as the concrete highway system of the country expands.

For other data on the subject reference is suggested to the following:

Practical Railway Painting and Lacquering.—By Hengeveld-Disney-Miskella. Published by Finishing Research Laboratories, Chicago.

Structural Metal Painting.—By A. H. Sabin, M.S.D.S. National Lead Company, 111 Broadway, New York.

Gast Portable Air Painters.—Gast Mfg. Co., Bridgman, Mich.

Paint Spraying Data.—The MacLead Co., Cincinnati, Ohio.

Instructions for Bridge Painting.—By E. E. Brandow, B. F. Dutch Boy Quarterly, Vol. 8, No. 2, 1930.

100 and 1 Ways to Save Money.—Ingersoll-Rand Company, 11 Broadway, New York.

General Paint Spraying Equipment.—General Pneumatic Tool Corp., Chicago, Ill.

Method of Securing Greater Efficiency and Economy in the Use of Labor-Saving Devices in Railway Track Maintenance.—A.R.E.A. Proceedings, Vol. 30, 1929, page 1124.

The Use of Compressed Air in Bridge and Building Work.—Committee No. 5, A.R.B.&B. Ass'n., October, 1926.

The following bibliography of articles on the subject have appeared in Railway Engineering and Maintenance since 1919:

Results Secured from Spray Painting.—December, 1919.

Use of Paint Brush Today or Wire Brush Tomorrow.—July, 1919.

Railroads Report on Spray Painting.—August, 1923.

Save Time, Money and Labor in the Repainting of Bridges.—December, 1923.

Mechanical Painting Reduces Cost.—Vol. 21 (1925) No. 1, page 9.

Spray Painting Proves Effective in Maintenance Department.—Vol. 22 (1926) No. 9, page 355.

The Application of Protective Coatings to Steel.—Vol. 22 (1926) No. 11, page 472.

B.&O. Uses Paint Spray to Advantage.—Vol. 23 (1927) No. 3, page 118.

Spray Painting of Buildings.—Vol. 24 (1928) No. 1, page 32.

A New Bitumen Spray Gun.—Vol. 24 (1928) No. 3, page 143.

The Painting of Railway Stations and Allied Buildings.—Vol. 24 (1928) No. 11, page 482.

Fairmont Combined Motor Car and Paint Spray Compressor.—Vol. 23 (1929) No. 3, page 127.

A New Spray Painting Unit.—Vol. 25 (1929) No. 8, page 356.

Painting With the Spray Gun.—Vol. 26 (1930) No. 4, page 184.

Spray Painting Outfits Improved.—June 1930, page 271.

Conclusions

(1) That there is a distinct saving in cost and a benefit in better results, greater durability and satisfactory appearance through the use of paint spray equipment.

(2) That railways are warranted in extending the use of spray equipment to small lattice work and trim on structures by the use of shields, proper equipment and various types of nozzles for that purpose and reduce brush work to a minimum.

(3) The greatest economies can be obtained by using spray equipment with specialized forces kept on this class of work.

Recommendations

The Committee recommends that this report be received as information and the conclusions printed in the Manual.

Appendix F

(6) REVISED PLANS FOR OUTFIT CARS FOR THE MAINTENANCE-OF-WAY DEPARTMENT EMPLOYEES

D. M. Rankin, Chairman, Sub-Committee; J. J. Baxter, N. W. Brown, A. N. Reece, F. R. Rex, William Shea, G. M. Strachan.

The Committee has made a study of the plans for outfit cars for the maintenance-of-way employees previously adopted by the Association and also those now being used on the railways most progressive in this line.

Radical improvements were found to have been made by many railroads in this type of equipment.

The revised plans are not fully developed for this year's report.

Recommendations

The Committee recommends that this report be received as information and the subject continued.

Appendix G

(7) ECONOMICS OF METHODS OF WEED KILLING

H. H. Harsh, Chairman, Sub-Committee; T. S. Bond, H. A. Cassil, J. A. Gorr, C. R. Knowles, D. M. Rankin, John Evans.

Data has been assembled as to methods of weed killing in Europe as well as in America, but the Committee reports progress only for this year, and recommends the subject be continued for further study.

Appendix H

(8) USE OF MOTOR TRUCKS IN MAINTENANCE-OF-WAY AND STRUCTURE WORK

H. M. Stout, Chairman, Sub-Committee; W. R. Bennett, H. H. Harsh, E. T. Howson, F. J. Meyer, F. R. Rex.

While the use of trucks in maintenance-of-way work by the various railways appears to be in its beginning and not yet extensive, the results obtained in many instances are favorable.

Due to the data and information for this study being received late in response to inquiries, the Committee does not feel justified in submitting final report this year and requests that the subject be continued for study during the ensuing year.

Appendix I

(9) GANG ORGANIZATION AND METHODS OF PERFORMING MAINTENANCE-OF-WAY WORK, INCLUDING REVISION OF TIME STUDIES NOW IN THE MANUAL

C. H. R. Howe, Chairman, Sub-Committee; N. W. Brown, J. F. Dobson, John Evans, H. I. Hoag, J. H. Kelly, J. A. Parant, G. M. O'Rourke.

Your Committee has given considerable study to the matter now in the Manual and has given special attention to a revised "Schedule for Renewing Rail Out-of-Face" showing the time distribution for 39-ft. rails, as well as the 33-ft. length. However, all developments are withheld pending further study of the subject and progress only is reported at this time.

Recommendations

The Committee recommends that the report be received as information only and the subject continued.

REPORT OF COMMITTEE VI—BUILDINGS

A. L. SPARKS, *Chairman;*
A. L. BECKER,
G. A. BELDEN,
ELI CHRISTIANSEN,
A. C. COPLAND,
J. H. DAVISON,
W. T. DORRANCE,
ALFRED FELLHEIMER,
HUGH FILIPPI,
E. A. HARRISON,
C. H. HIGGINS,
C. D. HORTON,
A. C. IRWIN,
F. R. JUDD,
W. N. KENNEDY,
W. L. LOZIER,
G. A. RODMAN, *Vice-Chairman;*
D. T. MACK,
E. K. MENTZER,
R. E. MOHR,
A. H. MORRILL,
J. W. ORROCK,
F. R. REX,
F. L. RILEY,
O. M. ROGNAN,
B. R. ROSENBERG,
A. B. STONE,
E. R. TATTERSHALL,
ARTHUR T. UPSON,
C. L. WENKENBACH,
O. G. WILBUR,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual. No changes are recommended at this time.

(2) Preparation of specifications for railway buildings (Appendix A).

It is recommended that the specifications be received as information with a view to their being offered for publication in the Manual at a later date and that the subject be reassigned for further study.

(3) Various types of train sheds (Appendix B).

It is recommended that the report on various types of trainsheds be received as information and the subject discontinued.

(4) Freight house doors (Appendix C).

It is recommended that the report on freight house doors be received as information and the subject discontinued.

(5) Use of welding in buildings, collaborating with Committee XV—Iron and Steel Structures.

It is recommended that since an extensive report on the use of welding in railway buildings is published in Vol. 32, pages 559 to 587 inclusive, your Committee has no further information to submit at this time and recommends the subject be discontinued.

(6) Sidewalks and station platforms, collaborating with Committees VIII—Masonry and XVII—Wood Preservation (Appendix D).

It is recommended that the report on sidewalks and station platforms be received as information and the subject discontinued.

(7) Modern methods of heating small railway buildings showing comparative advantages of warm air, hot water, steam and possibly fan-unit systems (Appendix E).

It is recommended that this subject be reassigned.

(8) Design and construction of modern fruit and produce terminal buildings, collaborating with Committee XIV—Yards and Terminals (Appendix F).

It is recommended that this subject be reassigned.

(9) Relative merits of wood and fireproof roof structures which should include wood, hollow tile fireproofing, concrete and cement tile, etc. (Appendix G).

It is recommended that this subject be reassigned.

Bulletin 343, January, 1932.

(10) Specifications for concrete used in railway buildings, collaborating with Committee VIII—Masonry (Appendix H).

It is recommended that the specifications for concrete for railway buildings, as now shown on pages 549 to 556 inclusive, of Vol. 32, be approved for publication in the Manual.

Respectfully submitted,

THE COMMITTEE ON BUILDINGS,

A. L. SPARKS, *Chairman.*

Appendix A

(2) PREPARATION OF SPECIFICATIONS FOR BUILDINGS FOR RAILWAY PURPOSES

F. R. Judd, Chairman, Sub-Committee; J. H. Davison, J. W. Orrock, B. R. Rosenberg, A. T. Upson, C. L. Wenkenbach.

The following specifications have been prepared and are submitted at this time for publication in the Proceedings and will be submitted later for publication in the Manual:

Section	30-A	Steel chimneys
"	30-B	Brick chimneys
"	30-C	Reinforced concrete chimneys
Addenda	A	Draft gages
"	B	Pyrometer
"	C	Lightning protection system

The Committee is holding in abeyance for further criticism and consideration, specifications published in Bulletin 323, as follows:

Section 10D, Types D1 and D2, Asphalt Impregnated Felt Roofing over wood or precast gypsum and over concrete or poured gypsum respectively; and
Section 28, Hydraulic Elevators, Baggage and Freight.

The Committee now has in course of preparation, specifications for electrically operated freight elevators, wood door and wood and metal frame window screens and two additional specifications for asphalt impregnated asbestos felt roofing, to be submitted at a later date.

SPECIFICATIONS FOR BUILDINGS FOR RAILWAY PURPOSES

Section 30–A

STEEL CHIMNEYS

1. General

The Contractor shall completely design and shall furnish all labor, material, tools and equipment, and construct a steel chimney of the height and diameter shown on drawings and as specified. The chimney shall be either self-supporting, or guyed, or stayed, as shown on drawings and as specified.

2. Design

The chimney shall be designed and constructed to withstand a horizontal wind pressure from any direction of twenty-five (25) pounds per square foot uniformly distributed over the entire vertical projection of the chimney, and also to withstand the total weight of the structure and the stresses caused by temperature changes.

Self-supporting chimneys over one hundred feet (100') high shall be belled or flared out at the bottom. The diameter of the bell or flare shall be determined by the type of foundation and the allowable unit stress, but shall in no case be less than one and one-half (1½) times the chimney diameter, and the height of the bell shall not be less than one-seventh (1/7) nor more than one-fourth (¼) the total height of the chimney above the foundation.

Chimneys inside of buildings shall be constructed in fireproof shafts and shall be rigidly connected to the framing at each floor. Framing shall be designed to resist the loads imposed by the chimney.

Guyed chimneys one hundred feet (100') or less in height shall be equipped with one (1) set of four (4) guys attached to the chimney at a point up two-thirds (⅔) of the height of the chimney. Guyed chimneys of a greater height shall be equipped with two (2) sets of four (4) guys each, one set attached to the chimney at a point up three-quarters (¾) of the height of the chimney, and the other set at a point one-half (½) of the height. Guys shall have a slope of from forty-five degrees (45°) to sixty degrees (60°) with the horizontal. Each guy of any set shall be designed to resist the entire wind load of the section of chimney to which it is attached.

Stayed chimneys shall meet all the requirements for guyed chimneys, except that there shall be half the number of stays as there are guys and each stay shall be designed for both tension and compression. Stays shall be placed ninety degrees (90°) apart in plan.

The successful contractor shall submit to the engineer for his approval, and before starting work, a complete set of his detailed calculations of the design of the chimney.

3. Unit Stresses

The chimney and its foundations shall be so designed that the following unit stresses shall not be exceeded:

Tension in steel plates	12,000 lb. per sq. in., net section
Compression in steel plates	10,000 lb. per sq. in., gross section
Shear in rivets and plates	9,000 lb. per sq. in.
Bearing on rivets and plates	18,000 lb. per sq. in.
Extreme fibre in bending	16,000 lb. per sq. in.
Tension in anchor bolts	16,000 lb. per sq. in., net section
Tension in guys	1/5 ultimate strength
Tension in stays	16,000 lb. per sq. in., net section
Compression in stays	18,000—60 l/r per sq. in.
2000 pound concrete, compression	400
2000 pound concrete, shear	60
Reinforcing steel, tension (intermediate grade)	18,000
Reinforcing steel, bond, deformed bars	100
Reinforcing steel, bond, plain bars	80
Ratio moduli elasticity steel and concrete	15

l—length of member in inches
r—least radius of gyration of member in inches

Bearing on soil	Determined by local conditions
Pile loading	Determined by local conditions

4. Foundation

The foundation and anchorages shall be designed to carry the chimney and all loads. For self-supporting chimneys it shall be so proportioned that the resultant of all forces will fall within such area that no tension or uplift will occur at the bottom surface of the foundation. Where piles are used they shall conform to the specifications of the American Railway Engineering Association.

5. Excavation

Excavation and backfilling shall comply with Section 2—Standard Specification for Excavation, Filling and Backfilling.

6. Concrete

Materials and workmanship for concrete when used in foundations, anchorages, etc., shall comply with Section 4—Standard Specification for Concrete Work.

7. Steel

Material and workmanship, except as noted, for the steel shall comply with Section 12-A—Standard Specifications for Structural Steel and Iron, unless otherwise specified. Copper-bearing steel, when called for on drawings, shall contain not less than two-tenths (0.2) of one (1) per cent copper.

8. Details of Steel Work

No metal less than one-quarter (¼) inch in thickness shall be used; and for chimneys or parts of chimneys subject to marked corrosion, no metal less than five-sixteenths (5/16) inch in thickness shall be used.

Plates forming the shell of the chimney shall be slightly conical so that the upper ring will always fit inside of the section below. Vertical seams shall be so located as to break joints. Lap joints with scarfed corners shall be used.

No rivets less than one-half (½) inch in diameter shall be used. Rivets shall be spaced not closer than three (3) diameters, nor further than sixteen (16) times the thickness of the thinnest plate. All rivets shall be power driven from the outside of the chimney.

Plates shall be bent cold after holes are made. Scarfed corners may be heated and shall be annealed if heated, but no other heating will be permitted. All holes shall be punched, reamed or drilled from the surface of contact. Plates five-eighths (⅝) inch or less may be punched; thicker plates up to and including three-quarters (¾) inch shall be sub-punched and reamed, and plates over three-quarters (¾) inch shall be drilled.

Connections for anchor bolts shall develop at least one and one-half (1½) times the full strength of the bolt.

Guys shall consist of galvanized steel wire guy strand of not less than seven (7) wires nor less than one-half (½) inch in diameter. No hemp or other non-metallic cores or centers will be permitted. Guys shall be fastened to the chimney at a horizontal joint by looping them over hot galvanized shackles or eye bolts fastened to a steel ring rigidly riveted to the shell. The loop shall be made over hot galvanized heavy pattern wire rope thimbles and the free end fastened by means of hot galvanized wire rope clips or clamps. The clips shall consist of U bolts and serrated drop forged steel saddles. Not less than two (2) clips shall be used for guys five-eighths (⅝) inch and less in size, three (3) clips for guys up to one (1) inch in size and four (4) clips for larger guys. The cut ends of guys shall be securely wrapped with galvanized wire to prevent unravelling. Connections to anchors, turnbuckles and elsewhere shall be made similarly as specified hereinbefore for connections to the steel ring of the chimney. Turnbuckles (hot galvanized) shall be provided at least six (6) feet and not over ten (10) feet above the ground for tightening each guy. Each guy shall be tightened carefully so that it takes its proper wind load. Connections, sockets, turnbuckles and anchorages for guys or stays shall develop at least one and one-half (1½) times the full strength of said guy or stay.

Where chimneys project through a roof a watertight collar or watershed shall be provided to prevent leakage through the roof or down any enclosing shaft.

9. Accessories

The Contractor shall furnish and install the following features and accessories, namely: Breeching opening, cleanout door, painter's collar and grounding for lightning protection.

When specified, the Contractor shall furnish and install the following features and accessories, namely: Chimney lining, ladder, draft gage and pyrometer.

10. Breeching Opening

The breeching opening shall be of the size, location and form shown on drawing and shall be reinforced with angles around the edges to receive the breeching.

11. Cleanout Door

The cleanout door opening shall be of sufficient size to enable the chimney to be cleaned out. The opening shall be reinforced at the edges with angles. The door shall be preferably of cast iron but it may be of steel plate reinforced with angles or plates. When the door is closed it shall be reasonably tight.

12. Painter's Collar

The painter's collar shall be of structural steel shape riveted to the chimney about two (2) feet from the top. There shall be provided a wire rope not less than three-eighths (3/8) inch in diameter and a bronze pulley of diameter not less than twenty (20) times the diameter of the wire rope.

13. Grounding for Lightning Protection

The chimney, guys and stays shall be grounded in such manner as to meet the requirements of the National Board of Fire Underwriters.

14. Chimney Lining

The chimney lining shall comply with the requirements of the National Board of Fire Underwriters and shall be designed to withstand a temperature of 1500 degrees Fahrenheit. The lining shall be brick of fire clay laid up with refractory mortar. Other suitable refractory linings complying with the requirements of the National Board of Fire Underwriters may be used at the option of the Engineer. Linings shall be rigidly attached to the chimney by anchors spaced not more than five (5) feet center to center. The lining shall extend from the foundation to a point not less than two-thirds (2/3) of the height from the top of the breeching opening to the top of the chimney, unless otherwise specified or ordered by the Engineer.

For chimneys enclosed in buildings the lining shall extend the full height from the foundation to the top of the building but never less than that specified above.

15. Ladder

The ladder shall be built preferably on the outside of the chimney and shall be of steel bars and safety rungs. The ladder shall be securely attached to the chimney by means of anchors spaced not more than eight (8) feet center to center. The ladder shall comply with local and State safety laws and requirements.

16. Draft Gage

The draft gage shall be of the pointer type as specified in Addenda A. The gage shall be installed in place complete with all attachments, piping and fittings, and

shall be in perfect working order. The location of the gage shall be indicated on the drawings and in a place visible to the operator when making adjustments to draft controls or dampers Each pointer or reading shall be furnished with stop cock close to the gage.

17. Pyrometer

The pyrometer shall be a vertical, straight stem, mercury actuated dial pyrometer, or a thermo-electric pyrometer equipped with dial and recording attachment, as may be determined by the Engineer. They shall be in accordance with the requirements of Addenda B.

18. Painting

All steel shall receive a shop coat of red lead and linseed oil. After erection it shall be cleaned of dirt, rust and scale, and given two (2) coats of an improved paint.

19. Guarantee

For a period of one (1) year after the completed chimney shall have been accepted by the Railroad Company, the Contractor shall repair free of charge any defect which may develop from a wind pressure due to a velocity of wind not exceeding one hundred (100) miles per hour, the influence of the atmosphere, the chimney gases and temperature not exceeding 1500 degrees Fahrenheit and faulty materials or workmanship.

20. General Conditions

All materials entering into the work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

The General Conditions in Section 1 of this specification shall apply with equal force in this section of the specification.

Section 30–B

BRICK CHIMNEYS

1. General

The Contractor shall completely design and shall furnish all labor, material, tools and equipment and construct the brick chimney of the height and size shown on drawings and as specified.

2. Design

The chimney shall be entirely self-supporting, independently of any building. Chimneys built in with buildings are covered under Section 5—Brickwork. The chimney shall be designed and constructed to withstand a horizontal wind pressure from any direction of twenty-five (25). pounds per square foot uniformly distributed over the entire vertical projection of the chimney, and also to withstand the total weight of the structure and the stresses caused by temperature changes. The design shall be such that the resultant of all forces will fall at any section within such area that no tension or uplift will occur.

Chimneys not greater than four (4) feet in least horizontal dimension nor greater than one hundred (100) feet in height, may be of square or rectangular section. Chimneys of greater least horizontal dimension or of greater height shall be of circular section. An octagonal cross-section may be used for the bottom section up to just above the entrance of the breeching.

The outside of the chimney shall be battered above the top of the chimney foundation. This batter shall vary from one-eighth (1/8) inch to five-sixteenths (5/16) inch in one (1) foot, the batter increasing as the ratio of the height to the top diameter increased.

The successful Contractor shall submit to the Engineer for his approval and before starting work, a complete set of his detailed calculations of the design of the chimney.

3. Unit Stresses

The chimney and its foundations shall be designed so that the following unit stresses in pounds per square inch shall not be exceeded:

Concrete or brick masonry in tension	None
Common brick, cement lime mortar 1-2-5 compression	200
Hard common select brick, cement lime mortar 1-2-5 compression	250
Pressed brick or sewer brick, cement lime mortar 1-2-5 compression	275
Paving brick, cement lime mortar 1-2-5 compression	300
Radial brickwork, cement lime mortar 1-2-5 compression	300
2000 pound concrete, compression	400
2000 pound concrete, shear	60
Reinforcing steel, tension (intermediate grade)	18000
Reinforcing steel, bond, deformed bars	100
Reinforcing steel, bond, plain bars	80
Ratio moduli elasticity steel and concrete	15
Bearing on soil—load to be determined by local conditions	
Bearing on piles—load to be determined by local conditions	

4. Walls

No chimney shall have a wall thickness at the top less than seven (7) inches for chimneys up to seven (7) feet in diameter; not less than eight (8) inches for chimneys from seven (7) feet to ten (10) feet in diameter; not less than nine (9) inches for chimneys from ten (10) feet to twelve (12) feet in diameter, and not less than thirteen (13) inches for larger chimneys.

At any section the walls shall be of such thickness that the unit stress specified hereinbefore shall not be exceeded, but in no case shall the thickness in inches be less than one-ninth (1/9) of the height of the chimney in feet above said section for paving brick or for radial brick, or less than one-ninth (1/9) of the height in feet plus four (4) inches for common brick. The walls of base section in inches shall not be less than one-ninth (1/9) of the height in feet plus seven (7) inches.

Chimneys shall be reinforced at every change in wall thickness with steel bands three (3) inches wide and three-eighths (3/8) inch thick, built into the walls, but in no case shall the bands be spaced more than twenty (20) feet apart.

5. Foundations

The foundations shall be designed to carry the chimney and all loads. It shall be so proportioned that the resultant of all forces will fall within such area that no tension or uplift will occur at the bottom surface of the foundation. In no case shall the width of the foundation slab be less than one-tenth (1/10) the height plus the inside diameter of the chimney at the top. The bottom of the foundations shall be approximately one-twenty-fifth (1/25) of the chimney height below the ground, but not less than four (4) feet deep. Where the foundation meets the chimney it shall be at least nine (9) inches larger than the outside diameter of the chimney.

Where piles are used they shall conform to the specifications of the American Railway Engineering Association.

6. Excavations

All excavation and backfilling shall comply with Section 2—Standard Specifications for Excavation, Filling and Backfilling.

7. Concrete

All materials and workmanship for concrete shall comply with Section 4—Standard Specifications for Concrete Work. Concrete for base shall be not less than 2000 pound concrete.

8. Brick

All brick shall comply with the Standard Specifications of the American Society for Testing Materials as follows:

Common brick with Grade "C" of Building Brick, serial designation C-62.

Hard common select brick with Grade "B" of the aforesaid specifications.

Pressed brick with Grade "A" of the aforesaid specifications.

Sewer brick with clay sewer brick, serial designation C-32.

Paving brick with paving brick, serial designation C-7.

Radial bricks shall be of best quality, moulded from refractory clay, and shall be sound, ringing, hard, well-burned, well-shaped, of reasonably even color and free from checks. They shall conform closely with the circular and radial lines of the shaft and shall be weather and acidproof. The radial brick shall have a water absorption of not less than five (5) per cent nor more than twelve (12) per cent of their dry weight after immersion in cold water for twenty-four (24) hours. The crushing strength of the radial brick shall be not less than six thousand (6000) pounds per square inch net section. The total perforations shall not exceed one-fourth (¼) of the gross cross-section area of the brick. One (1) cubic foot of radial brickwork shall weigh not less than one hundred twenty (120) pounds. The outside faces of the brick shall be of regular size so that the general appearance of the brickwork shall be neat and uniform.

Every fourth course shall be a header course for all brickwork except radial brickwork. For radial brickwork every third course shall be a header course.

9. Mortar

All mortar for the shaft of the chimney shall consist of one (1) part of Portland cement, two (2) parts lime putty and five (5) parts of torpedo sand.

Mortar for the lining shall be a refractory mortar.

Portland cement shall comply with specifications of the American Railway Engineering Association for Portland cement. Cement that has hardened or partially set shall not be used.

Sand shall be clean, sharp, coarse and free from sticks or other foreign matter. Clay or loam not to exceed two (2) per cent may be present. Grains shall be of varying size.

10. Accessories

The Contractor shall furnish and install the following features and accessories, namely: Breeching opening, lining, cleanout door and lightning protection.

When specified the Contractor shall furnish and install the following features and accessories, namely: Letters, ladder, draft gage and pyrometer.

11. Breeching Opening

The opening for the breeching connection shall be of such size and location, and of such form and finish as shown on drawings. The opening shall be lined on the reveals with refractory material. The masonry above the opening shall be supported on heavy

I-beams set on steel plates with a space at each end for expansion. Under these I-beams a flat masonry arch shall be built to protect the beams from the effect of gases. The opening shall be reinforced laterally by heavy tie rods and plates over top and bottom. Steel bands shall be provided above and below the opening.

12. Lining

The lining shall be constructed to the height above the top of boiler room floor shown on drawings. The lining shall start at least two (2) feet below the bottom of breeching opening, resting on a corbel in the shaft. Where there is danger of combustion below the breeching opening the lining shall start at the foundation which shall be paved with lining material of the same thickness as the bottom section of the lining if said foundation is of concrete.

For power boiler plants the lining shall be carried up above the top of the breeching opening at least one-quarter (¼) of the height of the chimney above the foundation; for temperatures ranging from 800 degrees to 120 degrees Fahrenheit, two-thirds (⅔) of said height, and for higher temperatures the full height.

The lining shall be constructed of high grade fire brick laid up in refractory mortar. The brick shall meet the requirements of the Standard Specifications of the American Society for Testing Materials for Clay Fire Brick for Stationary Boiler Service, serial designation C-64. For the radial brick chimneys the lining shall be of perforated radial brick of fire clay meeting the aforesaid requirements for brick for lining. Radial brick may be used for lining of other chimneys than those of radial brick.

The lining shall be not less than four and one-half (4½) inches thick and shall be built after the outer shell of the chimney is completed. It shall be entirely separated from the outer shell by an air space of not less than two (2) inches. The outer shell of the chimney shall be corbelled in over the top of the lining to prevent soot and other material dropping behind the lining.

The lining shall be built perfectly smooth, with the same batter as the inside of the chimney, and with bed joints not to exceed one-sixteenth ($\frac{1}{16}$) inch thick.

13. Cleanout Door

A cast iron cleanout door shall be provided not less than one foot four inches (1′ 4″) by two feet six inches (2′ 6″), hinged and latched to a cast iron frame placed at the base of the chimney.

14. Lightning Protection

The Contractor shall furnish and install complete in place a lightning protection system, as specified in Addenda C.

15. Lettering

When called for the Contractor shall build into the chimney shaft letters of permanently colored kiln burnt brick. The letters shall be of such number and dimensions as shown on drawings. The letters shall be true to size and shape, and in a true vertical line.

16. Ladder

The ladder shall be built preferably on the outside of the chimney, and shall consist of three-quarters (¾) inch square galvanized iron rungs, spaced approximately one foot three inches (1′ 3″) center to center and securely anchored into the masonry from top to bottom. The ladder shall comply with local and State safety laws and requirements.

17. Draft Gage

The draft gage shall be of the pointer type as specified in Addenda A. The gage shall be installed in place complete with all attachments, piping and fittings, and shall be in perfect working order. The location of the gage shall be indicated on the drawings and in a place visible to the operator when making adjustments to draft controls or dampers. Each pointer or reading shall be furnished with stop cock close to the gage.

18. Pyrometer

The pyrometer shall be a vertical, straight stem, mercury actuated dial pyrometer or a thermo-electric pyrometer equipped with dial and recording attachment, as may be determined by the Engineer. They shall be in accordance with the requirements of Addenda A.

19. Guarantee

For a period of one (1) year after the completed chimney shall have been accepted by the Railroad Company, the Contractor shall repair free of charge any defect which may develop from a wind pressure due to a velocity of wind not exceeding one hundred (100) miles per hour, the influence of the atmosphere, the chimney gases and temperature not exceeding 1500 degrees Fahrenheit, and faulty materials or workmanship.

20. General Conditions

All materials entering into the work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

The General Conditions in Section 1 of this specification shall apply with equal force in this section of the specification.

Section 30–C

REINFORCED CONCRETE CHIMNEY

1. General

The Contractor shall completely design and shall furnish all labor, material, tools and equipment and construct a self-supporting reinforced concrete chimney of the height and diameter as shown on drawings and as specified.

2. Design

The chimney shall be entirely self-supporting and independent of any building. The chimney shall be designed and constructed to withstand a horizontal wind pressure from any direction of twenty-five (25) pounds per square foot uniformly distributed over the entire vertical projection of the chimney and also to withstand the total weight of the structure and the stresses caused by temperature changes.

The walls shall be not less than four (4) inches thick at the top and shall increase uniformly to a thickness at the bottom which will be required to withstand the forces within the specified stresses.

The successful Contractor shall submit to the Engineer for his approval and before starting work, a complete set of his detail calculations of the design of the chimney.

3. Unit Stresses

The chimney and its foundation shall be designed so that the following unit stresses shall not be exceeded:

Concrete direct tension	None
Concrete diagonal tension	40 lb. per sq. in.
3000 lb. concrete, compression extreme fibre bending	500 lb. per sq. in.
2000 lb. concrete, compression extreme fibre bending	400 lb. per sq. in.
Concrete in shear	60 lb. per sq. in.
Steel in tension (intermediate grade)	18000 lb. per sq. in.
Bond, deformed bars	100 lb. per sq. in.
Ratio moduli of elasticity	15 lb. per sq. in.

Bearing on soil—Load to be determined by local conditions.
Bearing on piles—Load to be determined by local conditions.

4. Foundation

The foundation shall be designed to carry the chimney and all loads. It shall be so proportioned that the resultant of all forces will fall within such area that no tension or uplift will occur at the bottom surface of the concrete foundation. Where piles are used they shall conform to the specifications of the American Railway Engineering Association.

5. Excavation

All excavation and backfilling shall comply with Section 2—Standard Specifications for Excavation, Filling and Backfilling.

6. Concrete

All materials and workmanship for concrete shall comply with Section 4—Standard Specifications for Concrete Work, except that the maximum size of coarse aggregate for the shaft of the chimney shall be one (1) inch. Concrete for the shaft of the chimney shall be 3000 pound concrete and concrete for the foundation shall be 2000 pound concrete.

7. Forms

Either steel or wood forms of an approved design may be used, but shall be built in sections not to exceed five (5) feet in length. Forms shall be constructed in substantial and workmanlike manner, thoroughly braced, with smooth surfaces coming in contact with the concrete.

8. Accessories

Unless otherwise specified the Contractor shall furnish and install the following features and accessories, namely: Breeching opening, lining, cleanout door and lightning protection.

When specified or ordered by the Engineer, the Contractor shall furnish and install the following features and accessories, namely: Letters, ladder, draft gage and pyrometer.

9. Breeching Opening

The opening for the breeching connection shall be of such size and location and of such form and finish as shown on drawings. It shall have concrete collar and buttress.

10. Lining

The lining shall be constructed to the height above the top of the boiler room floor shown on drawings. The lining shall start at least two (2) feet below the bottom of breeching opening, resting on a corbel in the shaft. Where there is danger of combustion below the breeching opening the lining shall start at the foundation which shall be paved with lining material of the same thickness as the bottom section of the lining.

For power boiler plants the lining shall be carried up above the top of the breeching opening at least one-fourth (¼) of the height of the chimney above the foundation; for temperatures ranging from 800 degrees to 1200 degrees Fahr., two-thirds (⅔) of said height, and for higher temperatures the full height.

The lining shall be constructed of high grade fire brick laid up in refractory mortar. The brick shall meet the requirements of the Standard Specifications of the American Society for Testing Materials for Clay Fire Brick for Stationary Boiler Service, serial designation C-64. The lining may be of perforated radial brick.

The lining shall be not less than four and one-half (4½) inches thick and shall be built after the outer shell of the chimney is completed. It shall be entirely separated from the outer shell by an air space of not less than four (4) inches. The outer shell of the chimney shall be corbelled in over the top of the lining to prevent soot and other material dropping down behind the said lining.

The lining shall be built perfectly smooth, with the same batter as the inside of the chimney, and with bed joints not to exceed one-sixteenth (1/16) inch thick.

11. Cleanout Door

A cast iron cleanout door shall be provided not less than one foot four inches (1′ 4″) by two feet six inches (2′ 6″), hinged and latched to a cast iron frame placed at the base of the chimney.

12. Lightning Protection

The Contractor shall furnish and install complete in place a lightning protection system as specified in Addenda C.

13. Lettering

When called for, the Contractor shall place letters on the chimneys. The letters shall be of such number and dimensions as shown on drawings. The letters shall be formed by three-quarter inch (¾″) deep recesses in the concrete and painted black with two (2) coats of heat and acid resisting paint.

14. Ladder

The ladder shall be built preferably on the outside of the chimney, and shall consist of three-quarter (¾) inch square galvanized iron rungs, spaced approximately one foot three inches (1′ 3″) center to center and securely anchored into the masonry from top to bottom. The ladder shall comply with local and State safety laws and requirements.

15. Draft Gage

The draft gage shall be of the pointer type as specified in Addenda A. The gage shall be installed in place complete with all attachments, piping and fittings and shall be in perfect working order. The location of the gage shall be indicated on the drawings and in a place visible to the operator when making adjustments to draft controls or dampers. Each pointer or reading shall be furnished with stop cock close to the gage.

16. Pyrometer

The pyrometer shall be either a vertical, straight stem, mercury actuated dial pyrometer, or a thermo-electric pyrometer equipped with dial and recording attachment, as may be determined by the Engineer. They shall be in accordance with the requirements of Addenda A.

17. Guarantee

For a period of one (1) year after the completed chimney shall have been accepted by the Railway Company, the Contractor shall repair free of charge any defect which may develop from a wind pressure due to a velocity of wind not exceeding one hundred (100) miles per hour, the influence of the atmosphere, the chimney gases and temperature not exceeding 1500 degrees Fahr., or faulty materials or workmanship.

18. General Conditions

All materials entering into the work and all methods used by the Contractor shall be subject to the approval of the Engineer, and no part of the work will be considered as finally accepted until all of the work is completed and accepted.

The General Conditions in Section 1 of this specification shall apply with equal force in this section of the specification.

STEEL, BRICK AND REINFORCED CONCRETE CHIMNEYS

Addenda A—Draft Gages

1. General

The draft gage or gages shall be furnished and installed complete in place and in working order.

2. Indications for Natural Draft

For natural draft plants with hand fired grates, overfeed stokers, or oil or gas fired boilers, there shall be provided for each boiler unit a two (2) pointer draft gage with one (1) direct reading of draft in furnace above the grate, and one (1) direct reading of draft at uptake of boiler served by stack. The scale range for both readings shall be zero (0) to minus one (—1) inch of water. A common scale shall be provided for both pointers in order that the drop or differential through the boiler may be visibly indicated by the relative positions of the two pointers. For units served by chimneys greater than one hundred fifty (150) feet in height the gages shall be provided with seals to a total minimum pressure of two (2) inches of water without increase to scale range to provide maximum pointer travel and maximum responsiveness. The gage shall in all cases be provided with seals to a total pressure of not less than three-quarters (¾) of an inch of water for protection during soot blowing.

Where furnace draft only is desired a one (1) pointer draft gage with scale range from zero (0) to minus five-tenths (—0.5) inch of water shall be provided instead of the two gages specified above. The draft reading in this gage shall be multiplied ten (10) to one (1) on the scale.

Where firebox boilers are installed without provision for opening through side waterleg to permit piping for furnace draft, one (1) pointer draft gage for uptake draft only shall be provided with scale range from zero (0) to minus one (—1) inch of water.

In cases where two boilers are installed requiring operation of but one unit at a time, the second unit being for standby service, there shall be provided only one (1) gage with either one (1) or two (2) pointers. In either case the gage should be provided with a two-way cock for each pointer or reading so that indication of furnace and uptake drafts may be obtained from either boiler operated.

3. Indications for Forced Draft Grate

For forced draft plant with underfeed stoker or forced draft hand fired simple setting without preheater, economizer or induced fan, there shall be provided for each

boiler unit a three (3) pointer draft gage with a separate direct reading for the uptake draft for the furnace draft, and one for the windbox or pit pressure. The uptake draft shall have a scale range from zero (0) to minus one (—1) inch of water, the furnace draft a scale range from plus one tenth (+ 0.1) inch to minus nine-tenths (— 0.9) inch of water, and the windbox or pit pressure a range of from zero (0) to plus four (+ 4) inches of water.

It is recommended that range of windbox or pit pressure reading be determined only after inquiry of stoker manufacturer as to operating pressures required for best performance. It may be that lesser or greater ranges than those specified above are desirable. The lowest range which includes maximum operating condition to obtain maximum pointer travel and responsiveness shall be specified.

4. Indications for Forced Draft with Traveling Grate

For forced draft plants with traveling grate stokers, simple setting, no preheater, economizer, etc., no induced fan, there shall be provided for each boiler unit a multi-pointer draft gage with one (1) direct reading each of the following with corresponding ranges:

Windbox pressure ....Zero (0) to plus three (+ 3) inch water
Zone No. 1 pressure ....Zero (0) to plus three (+ 3) inch water
Zone No. 2 pressure ....Zero (0) to plus three (+ 3) inch water
Zone No. 3 pressure ....Zero (0) to plus three (+ 3) inch water
Zone No. 4 pressure ....Zero (0) to plus three (+ 3) inch water
Zone No. 5 etc., pressure ....Zero (0) to plus three (+ 3) inch water
Furnace draft ....Plus one-tenth (+ 0.1) minus nine-tenths (— 0.9)
Uptake draft ....Zero (0) to minus one (— 1) inch

It is recommended that ranges of duct, windbox and the several zone readings be determined only after inquiry of stoker manufacturer as to operating pressures required for best performance. It may be that lesser or greater ranges than suggested above are desirable. However, windbox and zones of traveling grate stoker shall be all of same range so that relative position of the several pointers will give a visible indication of the usual operating curve of air regulation throughout stoker grate. The lowest range which includes maximum operating condition to obtain maximum pointer travel and hence greatest responsiveness shall be used. When last zone on traveling grate stoker is only infrequently used under pressure, indication of this zone may be omitted, i. e., indicate only first four (4) zones of a five (5) zone stoker or furnish two (2) way cock on last zone indication to connect to last two (2) zones.

5. Indications for Induced Draft

For induced draft plants with economizer, preheater, induced draft fan, etc., there shall be provided for each boiler unit additional readings in multi-pointer draft gage as specified for forced drafts above with ranges as follows:

Windbox ....As specified below
Furnace ....Plus one-tenth inch (+0.1) to minus nine-tenths (—0.9) inch
Uptake or last pass ....As specified below
Economizer gas outlet ....As specified below
Preheater gas outlet ....As specified below
Induced draft fan ....As specified below
Forced draft fan ....As specified below
Preheater air outlet ....As specified below

To determine scale range for various draft indications in forced draft, induced draft installation, maximum pressure requirements of stoker and draft loss through each component part of unit such as boiler, economizer or preheater, must be obtained from

equipment manufacturer. The lowest range, which includes maximum operating condition, to obtain maximum pointer travel and hence greatest responsiveness, shall be used.

6. Indications for Pulverized Coal Plants—Direct Fired

There shall be provided for each boiler unit multi-pointer draft gages with one direct reading each of the following with ranges indicated:

Forced draft fan ....As specified below
Burner box header ....As specified below
Secondary air burner box ....As specified below
Primary air to mill ....As specified below
Exhauster from mill ....As specified below
Furnace ....Plus one-tenth (+ 0.1) inch to minus one-half (— 0.5) inch
Uptake or last pass ....As specified below
Economizer gas outlet ....As specified below
Preheater gas outlet ....As specified below
Induced fan ....As specified below

The above is merely suggestive of various draft indications necessary for intelligent control of air supply in pulverized fuel system. With any particular type or make of equipment certain readings will be indispensable and necessary to safe operation, some helpful to efficient results, while others may in some instances be omitted. Frequently a system will employ two or more mills and sometimes several burners per boiler unit. In such cases add points as required and label scales Mill No. 1, Mill No. 2, Burner No. 1, Burner No. 2, Burner No. 3, etc.

To determine readings and scale ranges required, equipment manufacturers should be consulted for air requirements and draft loss through component parts of the unit such as boiler, economizer and preheater as well as pressures required into and out of pulverizing mill, and at the burners for both primary and secondary air. The lowest range which includes maximum operating condition to obtain maximum pointer travel, and hence greatest responsiveness, shall be used.

Grouping of readings in common cases may be used to suit individual requirements and convenience of operation of boiler unit. Number of pointers or readings enclosed in one case is usually limited to twelve.

For readings in powdered coal stream there should be provided alundum filters to prevent stoppage in pipe lines, to insure accurate indication. There shall be provided for each reading in powdered coal stream a filter consisting of a porous alundum thimble three-quarters (¾) by three and one-half (3½) inches cemented into a brass plug one (1) inch i.p.t. tapped for pipe line fittings.

7. Seals

Draft gage shall be provided with seals, both plus and minus, to protect the gage from momentary excess pressures or surges beyond the scale ranges furnished. Unless otherwise specified hereinafter all minus readings shall be provided with a total plus seal of not less than three-quarters (¾) of one (1) inch of water to protect gage during soot blowing.

To provide seals required for various draft readings on forced or induced draft installations, it is suggested that a list of total plus and minus pressures to which each reading may be subjected, even though infrequently or momentarily, be included together with scale ranges desired as per example below.

	Seal Range	Plus Seal	Total Plus	Minus Seal	Total Minus
Windbox	0 to 4″	1 in.	5 in.	3 in.	3 in.
Furnace	Plus .10 to minus .90″	0.9 in.	1 in.	3.1 in.	4 in.
Uptake	0 to minus 1″	1 in.	1 in.	4 in.	5 in.
Econ. gas outlet	0 to minus 6″	1 in.	1 in.	2 in.	8 in.
Induced fan	0″ to minus 8″	1 in.	1 in.	0 in.	8 in.

These are suggestive only and specific figures for each installation will vary in accordance with design and equipment.

8. Gage Detail

Pointer draft gage shall be of the gasometer bell type in which the movement shall consist of a beam with fulcrum knife edges, incremental gravity load weight operated by a bell of ample displacement to obtain repetitively accurate readings at all points of the scale. Manufacturer shall guarantee error, if any, shall not exceed one-half (½) of one (1) per cent plus or minus.

No springs, bellows, diaphragms or gears will be acceptable. All metal shall be non-corrosive and outside surfaces shall be black finished to give neat appearance.

Range scales shall be at least 10″ in length, except for ranges under one inch (1″) of water, in which range scales shall be of such length that draft reading is multiplied not less than 10 to 1. Scales shall read directly in inches of water and figures shall be at least ½ in. high.

Gages shall be enclosed in dustproof metal case with removable front cover. It shall have a covered spout for oil filling from outside of gage.

Fulcrum knife edges shall be case hardened steel for all ranges above and including one inch (1″) of water. All other knife edges may be brass. Bearing shall be fitted with removable straps to prevent unseating or movement of bells by sudden pressure surges.

Bells shall be brass of true bore cylindrical form. Ratio of pointer travel to bell travel shall not be greater than five (5) to one (1), in which bell travel shall be not less than two (2) inches. No two pointer arms shall cross each other over the scale and pointer arrows shall lay close thereto. Pointer arms shall be of tapered channel type to minimize vibration.

Where two or more readings are combined in one gage the oil reservoir or pan shall be common to all readings for convenience in liquid level inspection and refilling. Drain for oil pan shall be provided.

Gages shall be calibrated for use with mineral oil of gravity 36 deg. to 39 deg. Baume.

Shut-off cock on each reading shall be furnished so that when the cock is closed the gage in either direction of the handle, is automatically vented on the gage side.

Where interior illumination of gage is not required and mounting is to be on wall or post—not on panel or instrument board—it is suggested the dial type of gage be specified for one, two or three pointers as follows: Pointer draft gage shall be furnished with dial type scale without interior illumination. Gage shall have covered opening for inspection of liquid level.

Where illuminated gage is required for mounting on post or wall, or panel of instrument board, the pointer draft gage shall be of the straight line movement type with translucent celluloid scales, illuminated from behind with a standard electric lamp of not less than fifteen (15) watts. Color code cards shall be furnished to indicate location of each reading.

Flanges shall be furnished for mounting gage in manner indicated below by check mark.

(a) Flush front for instrument panel .... inches thick, (projection 1").

(b) Wall or post mounting.

9. Piping and Connections

Piping into boiler furnaces through side walls, as indicated on plans, shall be of one (1) inch iron pipe with tee on the outside with plug in end of the tee for cleaning. To protect pipe from burning off, insert the pipe only part way through the wall beyond air space, if any, and close the space around the pipe with mortar to prevent in-leakage of air. Piping from this tee to gage shall be one-quarter (¼) inch iron pipe.

Piping into boiler uptakes, windbox, stoker zones, economizers, preheaters, ducts, etc., as indicated on drawings, shall be of one-quarter (¼) inch iron pipe with tee and plug at outside end.

Pipe shall be extended about one-quarter across the passage and shall be pointed either with or at right angles to the flow and not against the flow.

To protect against soot stoppage, the side outlet of all tees connecting with pipe lines through setting shall point up.

STEEL, BRICK AND REINFORCED CONCRETE CHIMNEYS

Addenda B—Pyrometer

The pyrometer shall be a vertical straight stem, mercury actuated, dial pyrometer, as specified below:

The stem shall be thirty (30) inches long including the thread. The pyrometer shall register any temperature ranging from 200 to 1000 degrees Fahrenheit. The dial shall be six (6) inches in diameter with nickel-plated brass case. The Contractor shall provide in the stack proper pipe connection for pyrometer in a convenient location above the flue connection, and shall be in either of the remaining three-quarters of the circumference of the chimney, and preferably where access is easy for observation. The connection shall project from the stack for a sufficient distance to enable pipe cap to be placed on end of same to keep the connection clean when the pyrometer is not in use.

Contractor shall submit an alternate proposal covering the furnishing and installing of an indicating and recording thermo-electric pyrometer to take care of range of temperatures outlined herein before. The instrument shall be placed in a most suitable location in the boiler or engine room, preferably on the master gage board. The recording portion of the instrument is to be designed for 24-hour readings and a year's supply of charts is to be provided. Thermocouple shall be of design to suit this particular installation. Where electricity is available the pyrometer shall be designed to suit the electric current at the site.

Contractor shall furnish in his proposal the manufacturer's name and specification of pyrometer he proposes to furnish and, if acceptable, no substitution will be permitted after proposal is accepted.

BRICK AND REINFORCED CONCRETE CHIMNEYS

Addenda C—Lightning Protection System

1. General

The lightning protection system shall be of an approved make and shall meet all the requirements and tests, and pass all inspections of the Insurance Companies, the

Code on Protection Against Lightning of the American Standards Association, and of the Underwriters Laboratories; shall bear the latter's label of approval, and shall comply with the requirements of this specification.

The system shall consist of two vertical conductors on opposite sides of the chimney connected at the bottom to two ground terminals and at the top to a ring encircling the stack not more than two feet below the top and carrying the air terminals. The air terminals shall be spaced not over six (6) feet apart, shall be even in number and in no case less than four (4) in number. They shall extend at least two feet 6 inches (2′ 6″) above the top of the chimney.

The vertical conductors shall each consist of seven (7) ropes of four (4) wires each, and each conductor shall have a total net cross-sectional area of 150,000 circular mills if the chimney is less than 150 feet high, and 250,000 circular mills if 150 feet high or over. Each vertical conductor, in one continuous length without cutting or splicing, shall form one-half of the circuit at the top of the stack, and shall be interconnected into the other half of the circuit. Each vertical conductor shall extend in one continuous length without cutting or splicing from the circuit at the top of the stack to the ground terminals.

One-half of the air terminals shall be connected directly to one of the vertical conductors, and the other half directly to the second vertical conductor by means of sections of cable running diagonally from the junction of the top ring and the air terminal to a point on the vertical conductor about fifteen (15′) feet below the ring.

The top ring and the diagonal cable lengths connecting the air terminals to the vertical conductor shall be of the same cross-section and material as the vertical conductor.

The conductor and cables shall be more than 99 per cent (99%) pure copper.

2. Air Terminals

Around the top of chimney the air terminals or point settings shall be equally spaced and set. Each shall consist of a pure, solid, hard, round copper bar extending about thirty (30) inches above top of chimney.

The base of point bar shall have at least a two (2) inch thread, screwed into a copper bronze inverted "V" lower point support firmly built into the masonry in which the horizontal and vertical cables shall be encased, lock-bolted and interior sweated solid.

Large multiple type points or series of points shall be mounted on top of each point bar or point setting by means of a long close-fitting thread. Each air terminal shall have six (6) solid metal tips which shall be of a non-melt composition of high heat resisting point metal. Each main point shall gradually taper from a globular base one and one-half (1½) inches in diameter into which five (5) smaller tips, each three (3) inches long and five-sixteenths (5/16) inch in diameter shall be screwed at an angle of 35 degrees from the horizontal. The diameter of the main point one-half inch from the top shall be not less than one-half inch. The diameter of the small points five-sixteenths (5/16) inch from the tip shall be five-sixteenths (5/16) inch. Each complete air terminal, including smaller points, from underside of globular base and the upper six inches of terminal bar, shall be sleeved with 100 per cent (100%) pure platinum 1/500 (.002) inch in thickness.

For chimneys 150 feet or more in height, points shall be mounted on three-fourths (¾) inch round, hard, pure solid copper bar.

For chimneys less than 150 feet in height, points shall be mounted on five-eighths (⅝) inch round, hard, pure solid copper bar.

3. Lead Armor

All parts of the lightning conductor system, except the platinum sleeved air terminal points, shall be encased in a chemical lead jacket one-sixteenth inch ($\frac{1}{16}$") in thickness to a point about twenty-five (25) feet below top of chimney. The lead shall be tightly lapped over the bottom of the platinum. The inverted "V" shaped connection between air terminal and conductor cables shall hermetically seal all lead sleeve ends making them acid, smoke and gasproof. The interior of this connection is then to be sweat soldered solid.

4. Protecting Pipes

Heavy copper or brass pipes shall encase the vertical conductors to a height of about twelve feet (12′) above ground level to protect the cables against theft or displacement. The pipes shall be durably and mechanically reduced and fitted and sweated to the conductor cables at top and bottom. The pipes shall be durably anchored to wall with extra heavy bronze supports.

5. Ground Terminals

About two feet (2′) below ground level a cable shall be spliced into each main cable making inverted Ys, the ends separated and carried in trenches to a distance of five feet (5′) apart where well holes shall be bored ten feet (10′) deep or deeper, if necessary, to insure permanently moist or wet earth. Each end of the "V" conductor shall be set-screwed and sweated into the tube center running the entire length of a perforated copper reservoir twenty-four inches (24″) long and four inchs (4″) in diameter at both ends with a copper head and copper bronze conical bottom. Each ground terminal reservoir, filled with pea-sized charcoal, shall be buried at the bottom of well hole in soft dirt.

6. Fasteners and Supports

All fasteners and supports shall be extra heavy copper bronze with improved double anchor tail of extra heavy type, anchoring inside masonry. Fasteners shall be set not to exceed two feet (2′) centers in horizontal lines and five feet (5′) apart in straight vertical lines. The first two fasteners above each protecting pipe shall be twelve inches (12″) or less apart.

7. Lightning Indicator and Test Gage

An efficient instrument for indicating lightning strokes shall be attached to one of the vertical conductors above the protection pipe at the base of chimney by attaching to the conductor system without cutting or breaking the main conductor cable circuit. The exterior case of this instrument shall be of aluminum and have a regulating attachment on the face so that it will register lightning strokes and when set can also be used for testing the lightning conductor system.

8. Connections, Splices, Workmanship, Etc.

All connections and splices shall be made in an electrically mechanical manner. All metal in the path of conductors shall be electrically connected. Conductors shall be erected in a neat, firm and workmanlike manner, free from sudden bends or kinks, by workmen trained and specializing in this class of work and who thoroughly understand every requirement of modern high class lightning conductor construction.

9. Guarantee

Should any portion of the protective system become defective or out of place due to natural wear or tear within a period of twenty-five (25) years, it shall be put in per-

fect condition by the Contractor at his own expense. Should chimney be damaged by lightning during this period, the Contractor will either make the necessary repairs or refund the cost of the damage up to the cost of protective system plus six per cent (6%) interest compounded per annum from date of payment for same.

Appendix B

(3) VARIOUS TYPES OF TRAIN SHEDS

G. A. Rodman, Chairman, Sub-Committee; Alfred Fellheimer, C. H. Higgins, C. D. Horton.

In this discussion the term "train shed" is intended to include all types of platform shelters and shelters for passenger trains at stations and terminals.

In order to gather information a form letter was sent out to all of the principal roads asking for prints and data on various types of sheds recently constructed.

The information received has been tabulated (see tabulation) to show the principal features. This shows a wide variety of design being influenced by the following conditions:

Geographical Location

1. Judging from the replies received the location geographically seems to have very little influence on the type of shed selected, except for an occasional point where a windbreak is combined with the shed, either by closing up one side or sheathing short sections along the center line.

Steam and Electric Operation

2. This seems to have little to do with the design as most sheds (except the Bush type) are at sufficient distance from center of track to allow clearance for overhead trolley or pantagraph.

Passenger Terminal or on Main Line, Both Passenger and Freight Service

3. When only passenger equipment is used it would seem to be the tendency to allow the shed roof to extend out to or over the car roof. This, however, is not permissable on tracks used by freight trains on account of the possibility of injury to men on top of cars.

General Appearance in Harmony with Adjoining Buildings

4. In most cases the sheds are attached to or adjacent to passenger station buildings and the design must conform to the style and class of station nearby, as it would obviously be inappropriate to put up an inferior type shed at an important station with new monumental buildings, so that it is common practice to have several types and classes of sheds.

Cost of Construction

5. This is usually commensurate with the cost of the station to which it is attached.

Cost of Maintenance

6. This is one of the principal factors in designing a shed and it should be the aim in every design to keep the future maintenance cost at a minimum. This pertains especially to the roof covering, conductors, gutters, etc.

Probable Life of Shed

7. This is one of the principal factors controlling the choice of type; that is, whether on permanent location or subject to changes in layout of tracks or platforms.

There are so many factors entering into the choice of design that it is difficult to line up any one recommended style.

The Balloon type of covershed was used quite extensively up to about twenty years ago, both for terminal stations and large through stations. This type of shed offers complete protection from rain and snow, but has the disadvantage of being drafty, dark, dirty, and very expensive to maintain.

The Bush type shed was considered by the Yards and Terminals Committee in 1924 (see pages 501 to 509, Vol. 25). The tabulation on page 503 covers data on fifteen different locations using some form of low shed extending over the tracks with openings to allow smoke to exhaust through the roof. The Bush type shed has now largely taken the place of the balloon shed, where complete protection is desired, but due to its high cost is limited to important terminal stations where passenger equipment is handled exclusively.

The Umbrella type is cheaper to construct but has the disadvantage of having the conductors and gutters on the outside edge where they are subject to frequent damage and liable to freeze up.

The roof, unless covered with some expensive covering, is unsightly and requires frequent repair.

The Butterfly type has the following good features: Absence of gutter and conductor on outer edge, all conductors lead directly down the center post lessening the liability of freeze up and stoppage.

The roof covering is hidden, allowing the use of an inexpensive durable built-up roof.

Except for terminal stations where the Bush type shed is desirable, the Committee recommends the use of the Butterfly type, single post construction, built so far as feasible of standard steel shapes, with smooth surface built-up roof. Wrought iron conductor pipes at least up to six feet above platform with the following given consideration:

When there are stairways in center of platform, use two-post construction with glazed windbreaks extending up to the under side of the roof.

Where terminal platforms are used only by passenger trains, roof may extend out to the gage line of track and high enough to give clearance for cars and engines.

For main line sheds, where both passenger and freight trains are operated, the roof shall extend out to the standard clearance line, and the height to be only sufficient to clear loaded trucks and provide for clearance for refrigerator car doors.

In all cases the roof pitch should be only sufficient to give good drainage.

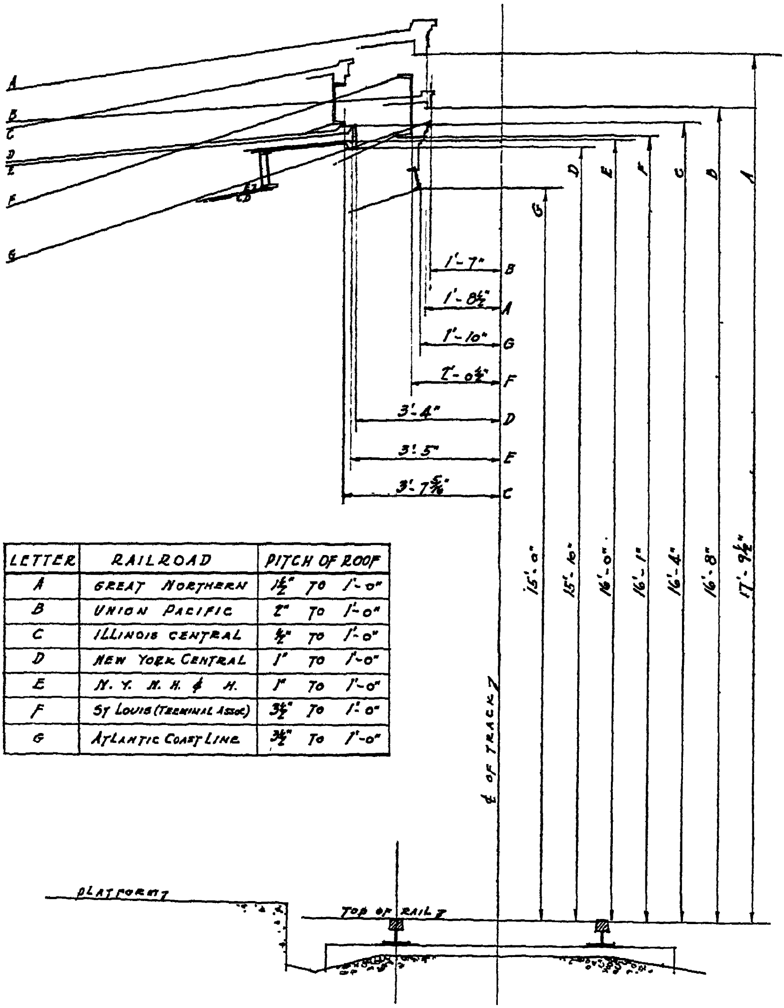
The following tabulation shows the types of sheds used by various roads and indicates the popularity of the Butterfly type.

Train Sheds

Name of Road	Location	Type	Posts	Roof Framing	Roof Deck	Height Edge of Overhang Above Top of Rail	Distance C/L of track to Edge of Overhang
N. Y., N. H. & H.	Franklin, Mass.	Canopy	Wood	Wood	Wood	9'– 6"	----------
	Boston, Mass.	Butterfly	Steel	Steel	Wood	16 – 0	3'– 5"
	Back Bay, Boston, Mass.	Butterfly	Steel	Steel	Wood	16'– 0"	3'– 8"
	New Haven, Conn.	Butterfly	Steel	Steel	Wood	10'– 7"	7'– 0'
	Port Chester, N. Y.	Butterfly	Wood	Wood	Wood	14'–10"	4'– 8"
	Yarmouth, Mass.	Canopy	Wood	Wood	Wood	8'– 9"	7'– 0"
	Saybrook Jct., Conn.	Canopy	Wood	Wood	Wood	10'– 0"	7'– 0"
Denver, Rio Grande & Western	Salt Lake City, Utah	Butterfly	Steel	Steel	Wood	16'– 0"	4'– 0"
Great Northern	Seattle, Wash.	Butterfly	Steel	Steel	Wood	13'– 8"	----------
	Bellingham, Wash.	Butterfly	Wood	Wood	Wood	12'– 2"	8'– 0"
	Minneapolis, Minn.	Butterfly	Steel	Steel	Wood	18'– 0"	1'– 6"
Missouri-Kansas-Texas Lines	Houston, Texas	Butterfly	Steel	Steel	--------	15'– 2"	----------
	Highland Park, Tex.	Butterfly	Wood	Wood	Wood	15'– 6"	----------
St. Louis–San Francisco	Typical Design	Butterfly	Steel	Wood	Wood	16'– 8"	5'– 6"
Erie	Ridgefield Park, N. J.	Lean To	Steel	Steel	Wood	18'– 0"†	----------
	Ridgefield Park, N. J.	Lean to	Steel	Steel	Wood	18'– 0'†	8'– 0"
	Patterson, N. J.	Butterfly	Steel	Steel	Wood	15'– 0"†	3'–11"†
	Englewood, N. J.	Canopy	Wood	Wood	Wood	12'– 0"†	8'– 6"
Term. R. R. Association of St. Louis	St. Louis Union Station	Butterfly	Cast I.	Steel	--------	16'– 1"	2'–0½"
Pere Marquette	Muskegon	Butterfly	Steel	Steel	Steel	12'-10"†	----------
Atchison, Topeka & Santa Fe	Emporia, Kansas	Butterfly	Concrete	Concrete	--------	16'– 6"	5'– 8"
	Typical Design	Butterfly	Steel	Steel	--------	16'– 2"	4'– 2"†
	Typical Design	Butterfly	Concrete	Concrete	--------	16'– 2"	4'– 6"
	Typical Design	Butterfly	Steel	Wood	--------	16'– 2"	4'– 0"
	Typical Design	Butterfly	Cast I.	Wood	--------	16'– 2"	4'– 4"
Union Pacific	Omaha, Nebraska	Butterfly	Steel	Steel	Wood	17'– 6"	3'– 7"†
Reading	Trenton Jct., N. J.	Butterfly	Steel	Wood	Wood	14'– 6"†	8'– 0"
	No. Broad St. Sta., Philadelphia	Butterfly	Cast I.	Wood	Wood	16'– 0"†	----------
Baltimore & Ohio	Typical Design	Butterfly	Cast I.	Wood	Wood	15'– 0"†	----------
Pennsylvania	Lancaster, Pa.	Butterfly	Cast I.	Steel	--------	11'– 2"	----------
	Harrisburg, Pa.	Butterfly	Wood	Wood	Wood	13'– 6"	----------
Illinois Central	Chicago Terminal	Butterfly	Wood	Wood	Wood	10'– 9"	7'– 6"
	Typical Design	Butterfly	Wood	Wood	Wood	15'– 6"	8'– 0"
	Typical Design	Butterfly	Wood	Wood	Wood	15'– 6"	8'– 0"
	Baton Rouge, La.	Butterfly	Cast I.	Wood	Wood	15'– 6"	5'– 3"
	Champaign, Ill.	Butterfly	Cast I.	Wood	Wood	15'– 6"	----------
	Jackson, Miss.	Butterfly	Steel	Steel	Wood	17'– 0"	1'– 6"
Central of N. J.	Cranford, N. J.	Canopy	Steel	Wood	Wood	9'– 0"	----------
Rich., Fred. & Potomac	Richmond, Va.	Butterfly	Cast I.	Steel	Wood	15'– 6"	2'– 8"
Chicago, Burlington & Quincy	Omaha, Neb.	Butterfly	Steel	Steel	Wood	17'– 6"†	----------
	Lincoln, Neb.	Butterfly	Steel	Steel	Wood	12'– 0"	8'– 0"
	Aurora, Ill.	Butterfly	Concrete	Concrete	Concrete	12'– 8"	----------
Atlantic Coast Line	Wilmington, N. C.	Butterfly	Steel	Steel	Wood	15'– 0"	1'– 8"
	Haines City, Fla.	Butterfly	Cast I.	Wood	Wood	13'– 6"†	----------
	Selma, N. C.	Butterfly	Cast I.	Wood	Wood	15'– 6"†	4'– 6"†
	Sanford, Fla.	Canopy	Cast I.	Wood	Wood	10'– 4"†	----------

Train Sheds (Continued)

Name of Road	Location	Type	Posts	Roof Framing	Roof Deck	Height Edge of Overhang Above Top of Rail	Distance C/L of track to Edge of Overhang
Gulf, Colorado & Santa Fe	Galveston, Texas	Butterfly	Steel	Steel	Concrete	--------	--------
Northwestern Pacific	Fairfax	Canopy	Wood	Wood	Wood	10″– 2″	9′– 1″
	Sausalito Terminal	Butterfly	Wood	Wood	Wood	--------	--------
Norfolk & Western	Typical Design	Butterfly	Steel	Steel	Wood	13′– 8″†	7′– 6″
	Portsmouth, Ohio	Butterfly	Steel	Steel	Wood	12′– 6″†	8′– 0″†
Delaware, Lack. & Western	Typical Design	Canopy	Concrete	Concrete	Concrete	12′– 6″	6′– 9″
	East Orange, N. J.	Butterfly	Concrete	Steel	Concrete	--------	--------
	Typical Design	Canopy	Concrete	Concrete	Concrete	12′– 6″	6′– 9″
	Lyndhurst	Butterfly	Concrete	Wood	Wood	13′– 6″	8′– 0″
	Glen Ridge, N. J.	Butterfly	Concrete	Wood	Wood	12′– 8″	--------
	Ampere, N. J.	Canopy	Concrete	Wood	Wood	--------	--------
	Montclair, N. J.	Canopy	Steel	Steel	Concrete	--------	--------
New York Central	Marble Hill, N. Y.	Canopy	Wood	Wood	Wood	18′– 6″†	8′– 0″†
	Harmon, N. Y.	Butterfly	Steel	Steel	Wood	--------	--------
	Van Cortlandt, N. Y.	Canopy	Steel	Wood	Wood	9′– 2″†	8′–10″
	Buffalo Terminal	Butterfly	Steel	Steel	Concrete	16′– 6″	1′– 3″
	Dobbs Ferry	Butterfly	Steel	Steel	Wood	13 – 4″†	--------
	Buffalo Terminal	Butterfly	Steel	Steel	Concrete	16′–¼″	3′– 0″†
Southern	Durham, N. C.	Butterfly	Wood	Wood	Wood	15′– 6″	3′– 9″
	Danville, Va.	Butterfly	C. I. Pipe	Wood	Wood	12′– 0″†	7′– 6″
	Greensboro, N. C.	Butterfly	Steel	Steel	Wood	15′–0½″	3′– 9″
Kansas City Southern	Shreveport, La.	Butterfly	Cast I.	Wood	Wood	15′– 6″	8′– 0″



LETTER	RAILROAD	PITCH OF ROOF
A	GREAT NORTHERN	1½" TO 1'-0"
B	UNION PACIFIC	2" TO 1'-0"
C	ILLINOIS CENTRAL	½" TO 1'-0"
D	NEW YORK CENTRAL	1" TO 1'-0"
E	N. Y. N. H. & H.	1" TO 1'-0"
F	ST LOUIS (TERMINAL ASSOC)	3½" TO 1'-0"
G	ATLANTIC COAST LINE	3½" TO 1'-0"

· CLEARANCE COMPARISON ·

COVERSHEDS OF VARIOUS RAILROADS

Appendix C

(4) FREIGHT HOUSE DOORS

J. W. Orrock, Chairman, Sub-Committee; A. C. Copland, W. N. Kennedy, Eli Christiansen.

The following types of doors are those most generally used for freight rooms, express rooms, baggage rooms and mail rooms.

SINGLE SLIDING DOORS

Ordinary Wood Doors

The ordinary wood door of built up construction is usually of white pine or cypress or other species of wood adaptable to exterior use and climatic conditions where used. The thickness varies according to size of door and in general is about 2¾ in. for the average door, and glass panels, if required, can be provided.

Doors of this type are usually hung on metal hangers bolted to the door frame, and supported above by a metal runway, and are manually operated. For easy operation trolleys should be kept lubricated and doors and hardware painted regularly to keep them from deteriorating. Single sliding doors require considerable wall space between doors.

Mill Type Doors

This type of door consists of a metal frame and a laminated wood filler. The metal frame forms the hanger and the wood filler consists of 1¾ in. square tongued and grooved strips. The wood strips are nailed through the tongue and groove, piece by piece, to each other, and the strips next to the metal are nailed to the frame. The wood strips are painted before fitting and no nails are exposed. This type of door is exceptionally strong and rigid, and being hung on a metal frame there is little or no strain on the wood, and consequently no sagging or pulling apart, such as is experienced with the ordinary wood door. They are supported on overhead metal runways similar to the ordinary wood door.

Corrugated Sheet Metal Doors

This door consists of two layers or thicknesses of galvanized corrugated sheet metal with a layer of sheet asbestos between and reinforced with structural steel frame members. The corrugations on one side of the door are horizontal and on the opposite side vertical and can be provided with glass panels if required. This door, while rigid, is more readily damaged than the wood door, requires more maintenance, especially painting, to prevent corrosion. This type of door is suitable as a fire door and used extensively for this purpose, and is supported on metal hangers and overhead runways similar to the ordinary wood door.

Tin Clad Doors

These doors are used generally on interior fire walls and are usually made of three thicknesses of boards, dressed to $\frac{13}{16}$ inch full, the outside layers vertical and inner layer horizontal, thoroughly fastened together by wrought iron clinch nails not over eight inches apart, extending clear through the door and clinched on the back side, leaving both surfaces of the door smooth, and then clad in tin, with double lock joints in the tin covering, with the necessary hangers, track, fixtures and fusible links, as required by the rules of the Fire Underwriters. Door may be either sliding or swinging. This type of door requires to be well maintained, the wood core is subject to dry rot.

Steel Doors

Steel doors consist of heavy pressed metal sheets fabricated in the shop. Joints are fitted, reinforced, welded and dressed to produce neat connections. Hardware and track are applied similar to other doors already described.

Rolling Wood Doors

While steel is the more common of the two types of rolling doors, wood rolling doors are also obtainable, but not as widely used as the steel type. They are installed and operated in a similar manner to rolling steel doors. Possibly one advantage of the wood over the steel rolling door is that it is not subject to corrosion. However, it would appear that a disadvantage of the wood rolling door may be the possibility of the wood slats shrinking, swelling and warping due to atmospheric changes.

Rolling Metal Doors

For single or continuous openings divided by posts, rolling metal doors are often used. These doors take up very little wall and overhead space. They can not be satisfactorily glazed. This type of door consists of a curtain of interlocking steel slats, which are coiled upon an enclosed barrel or roller overhead and travels in steel guides mounted at the sides of the openings. Rolling steel doors can be mounted in several ways, directly above the opening either in or outside of the building or, if head room is limited, in the opening directly under the lintel. The use of the rolling steel door permits a wide range of opening sizes not attainable by the use of some of the other types of doors. Except for small openings, which are manually operated, they require a chain hoist or electrically driven operating device for proper operation. One disadvantage of this type of door is that if the slats are damaged or bent when door is in closed position, the opening is put out of service until the door is removed, necessary repair parts received and the door repaired. Rolling steel doors should be painted regularly to prevent deterioration, all parts properly lubricated and kept in good condition for easy and efficient operation.

Overhead Wood Doors—Light Construction

At present there are many different varieties of this type of door, all having their advantages. This type of door usually has 1¾" thick rails and stiles, with ⅜" thick veneer panels. Each door is in varying number of sections, can be glazed if required, and is equipped with necessary hardware, tracks, hangers, counterweights, springs, etc., required for operation. Some types slide up and fold overhead, others slide up, turn and roll overhead. Some of the varieties of light construction overhead doors now being marketed are limited to small openings while others can be had for large openings. These doors are very light and easily operated, some manually while others require chain hoists. They are primarily designed for private garages, service stations, etc., but are adaptable for some types of railroad construction. Any particular merits or maintenance requirements in connection with their use on railroads are not determinable at this time.

Overhead Door—Heavy Construction—Wood or Metal

Under this heading of doors, there are various types of all wood construction, mill type construction, and metal construction. Some of the more common types are Bifolding Doors, Single and Double Section Turnover Doors, Sectional Overhead Doors, etc. The different types of construction correspond to those described before under the preceding articles. These types of doors are adaptable to either single openings or partially continuous openings, such as are divided by posts, columns or narrow masonry piers. The Bifolding type slides up and folds in two while ascending, Single and Double

Section Turnover Doors slide up, turn and roll overhead, and the Sectional Overhead Doors operate in a similar manner. All of these types have their advantages, most of which have previously been described. One disadvantage, especially of the Single and Double Section Turnover Door and the Sectional Overhead Door, is that when it is in a raised or open position, it occupies considerable space overhead, which in many instances interferes with the overhead electric lighting. The doors of this type can be manually operated for the smaller openings, but in general required either chain hoists or electrically driven operating devices. Maintenance of these doors is about the same as previously described.

Vertical Lift Doors—Wood or Metal

Vertical lift doors can be used for any class of opening and can be of types of construction heretofore described. This type of door requires considerable head room along the face of the wall directly above the openings. These doors are of single, double or multiple sections and of one, two or more speeds. Various methods of operation are used, such as manually, chain hoists and electrically driven operating devices. All counterweights and moving parts should be suitably guarded.

After installation doors must be periodically inspected to see that cables, pulleys, etc., are in proper condition to carry the load and prevent accidents.

Continuous Sliding Doors

Where continuous openings are desired, parallel sliding doors are hung on two lines of overhead tracks, and continuous slots or grooves at the floor level are provided in which the doors are held in place and prevented from moving laterally.

Continuous door installations permit the placing of cars along building without any great care in spotting cars, for any section of the freight house, etc., can be opened by simply sliding the doors opposite the car doors.

Special arrangements are sometimes provided for weather-stripping the bottom with metal strips attached to the doors sliding in slots or grooves, where weather tight enclosures are required.

Continuous door installations can be made, using doors of wood or metal of the construction already described under single sliding doors and are subject to the drawbacks or advantages already described for each particular door.

Appendix D

(6) SIDEWALKS AND STATION PLATFORMS, COLLABORATING WITH COMMITTEE VIII—MASONRY AND COMMITTEE XVII—WOOD PRESERVATION

A. C. Irwin, Chairman, Sub-Committee; W. L. Lozier, O. M. Rognan, F. R. Rex.

PLATFORMS

General

The selection of type and character of platform for a particular location depends upon the kind and volume of traffic, exposure to the elements, probability of future change of line or grade and character of the station.

Passenger platforms constitute an important contact of railways with the traveling public, and attractive appearance has an advertising value that should receive consideration. The better class are surfaced with brick, concrete or asphaltic materials, while

unpaved filled or wood types are used where conditions warrant them. In any case, proper design, finished workmanship and sufficient maintenance are essential.

Freight platforms at receiving, delivering and transfer stations require surfacing materials capable of resisting wear of truck traffic. The surface of such platforms are subject to more severe service than sidewalks or highways because of iron or steel wheeled trucks and handling of heavy freight.

The use of rubber-tired truck wheels will reduce maintenance and handling costs on hard surface platforms.

In the selection of platform surfacing material for a certain location, the following should be given consideration:

(a) Appearance.
(b) Cost of operating trucks (including tractive resistance) unless for passenger service only.
(c) First cost.
(d) Yearly maintenance.
(e) Service life.
(f) Noise.
(g) Smoothness and regularity of surface with special reference to loss and damage claims.
(h) Safety.

CHOICE OF TYPE

Unpaved Filled Platforms

The low first cost of the unpaved filled type makes it suitable for unimportant way-stations and temporary construction.

Loose types of pavement function unsatisfactorily under heavy traffic and severe exposure. They are dusty in dry weather and become mushy and muddy under foot in thawing weather. Other disadvantages are relatively high maintenance, generally poor surface and appearance and fouling of shoes, station and car floors with mud or dirt.

The surface of unpaved filled platforms is often improved by the application of stone screenings, watered and rolled, or a thin coat of screenings with an asphalt binder.

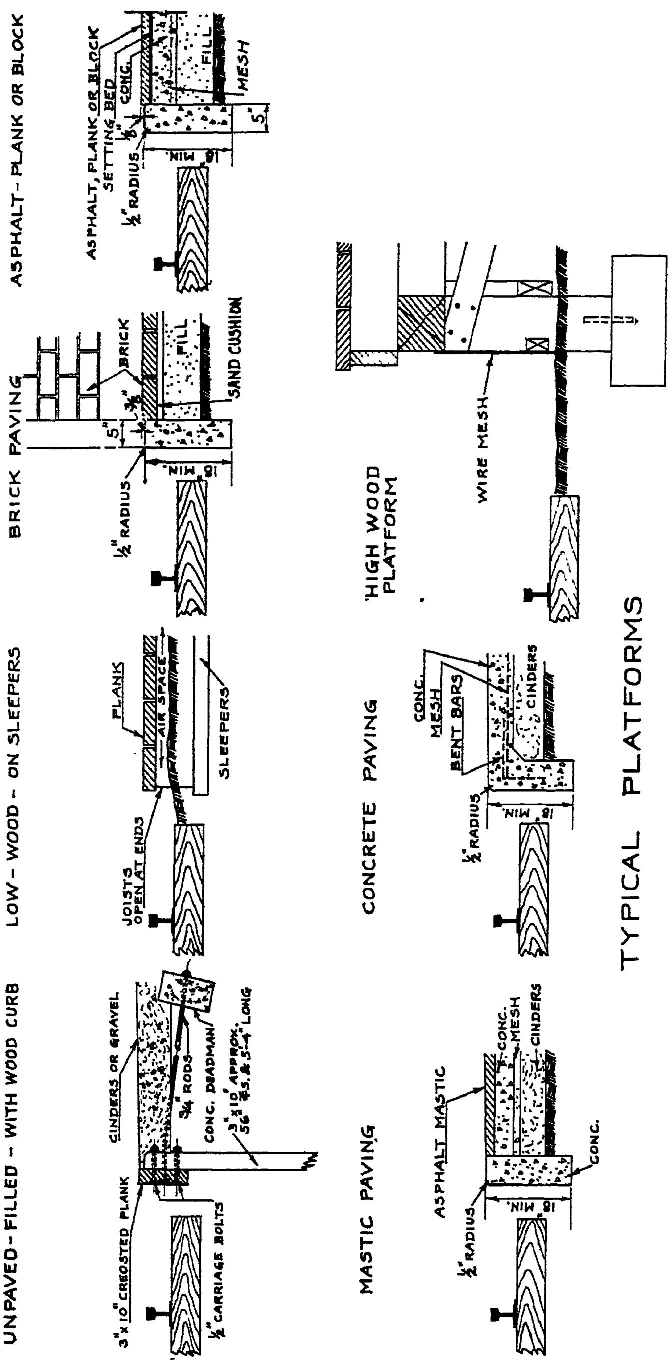
Wood Platforms

The use of untreated wood exposed to the weather is appropriate for temporary locations or dry localities. Untreated sleepers resting on or embedded in the ground are short lived. Plank on joists or sleepers will last longer due to better ventilation. Joists and/or stringers supported on blocking or posts will last eight or ten years before increasing maintenance makes renewal imperative. The average life of untreated uncovered wood plank platforms for freight trucking in the Southwest is about six to nine years, depending on traffic, location and kind of lumber. Properly treated timber will last longer under all of these conditions except where maintenance is due to wear from traffic. Maple or other hardwood plank or boards are generally satisfactory for severe trucking service.

Brick Platforms

A hard burned shale brick exterior platform surface has good appearance, wears well, may have salvage value, and is easily repaired. Such platform surfaces, however, require a thoroughly compacted foundation and are suitable for low passenger platforms.

First-class vitrified shale brick have a high resistance to abrasion and when properly laid will stand heavy trucking. It is difficult to clean snow thoroughly from brick surfaces and they are noisy under steel tired trucks.



TYPICAL PLATFORMS

Asphalt Platforms

Preformed asphalt plank or block and mastic asphalt platforms have been used in passenger and freight stations. Steel-tired trucks on asphalt surfaces are less noisy than on hard surfaces.

Asphalt surfaces may be repaired without much traffic interference.

Asphalt surfaces function better under trucking than under piled or standing loads—particularly in hot weather. Cast in place asphalt mastic, where not subjected to truck traffic tends to crack up and become unsightly.

The degree of success in the use of asphalt mastic surfaces will be measured largely by selection of the proper proportions and kinds of ingredients and intelligent application of them.

Concrete Platforms

Concrete has been extensively used for platforms in both major and minor freight and passenger stations. It has the advantage of cleanliness, good appearance and ease with which snow and ice can be removed. It is economical as to first cost where a hard surface is required and offers low resistance to trucks so long as the surface remains smooth and is adapted to high as well as low platforms. If subjected to rubber-tired traffic only, a well built concrete platform will give long service without much maintenance expense and meets the requirements of whatever fire hazard there may be present.

Precast slab platforms have been used to a limited extent and have some advantages.

Heavy traffic with iron or steel-tired trucks will, in time, abrade concrete surfaces especially at necessary expansion and construction joints unless special construction at such places is used.

The noise of steel tires on concrete surfaces may be objectionable.

Repairs to concrete platforms interfere with their use, and unless properly done will not be permanent. The use of high early strength concrete will minimize the time required for curing but in any case experienced and intelligent workmanship is necessary for best results.

DESIGN AND CONSTRUCTION

General

Standard designs to cover all localities, size of station dimensions and other requirements are impracticable, but some suggested designs are presented.

Width

(a) Passenger island platforms used for foot traffic only should provide a line of travel for passengers from an arriving train and a line of travel for passengers to a departing train. A minimum width of 13 feet is recommended. Traffic to departing trains (except suburban trains) will be much lighter than from arriving trains, but a width to accommodate passengers from two trains arriving simultaneously is not justified.

(b) Combined passenger and trucking island platforms for normal conditions should preferably be 18 feet wide. This will allow space for one truck, one row of columns and one line of traffic to and from trains.

(c) Combination platforms in front of medium sized stations should preferably be not less than 20 feet wide.

(d) Exclusive trucking platforms should be free from columns if practicable. They should provide room for trucks to pass. Hand trucking platforms between tracks should be at least 8 feet wide if uncovered, and 10 feet wide if covered. Freight house plat-

forms on track side should be at least 8 feet wide for hand trucking and 12 feet for power trucks.

(e) The minimum width at way stations where baggage, mail and some express are handled, should preferably be 15 feet.

(f) Freight transfer platforms with one row of columns carrying butterfly or umbrella canopy should preferably be not less than 12 feet wide for hand trucking and 13 feet wide if tractors and trailers are used.

Height

Low passenger platforms should never be lower than top of rail, and preferably not less than 4 inches above it to allow for lift of track if on ballast.

Passenger platforms at car floor level in large terminals are safer and much more convenient than low platforms and save time particularly in discharging passengers. Trucking platforms in large passenger terminals should be of sufficient height to bring the truck to an approximate level with the car floor.

Loading

High passenger platforms not supported directly on fill should be designed for a normal live load uniformly distributed of 100 pounds per square foot, and freight platforms for 300 pounds per square foot. If the platform will be subjected to abnormal load concentrations, it should be designed accordingly.

Drainage

Adequate drainage should be provided by sloping the surface from the building to the curb and island platforms should be crowned. A system of gutters and down spouts should be provided for covered platforms.

Safety

The practice of painting a broad line parallel to the tracks to indicate a safe limit of distance from the edge of the platform is recommended. Ends of high platforms should be protected with a substantial railing and ends of low platforms should be sloped off to the ground if the height at end is over 6 inches. The use of anti-slip surfaces on passenger platforms should be given consideration as a safety measure. A smooth, hard troweled surface should be avoided on a concrete platform. Carborundum grains are sometimes applied in finishing concrete platforms to provide a non-slip surface.

Curb

A curb should always be provided alongside tracks. If it is not designed as a retaining wall it should be anchored into the filling material. For island platforms, the anchorage may well pass through the fill from curb to curb. More permanent curbs are constructed of stone or concrete and these are sometimes anchored downward into the soil in cold climates to prevent heaving by frost.

Filling and Subgrade

The ground under the fill should be leveled off and soft spots dug out and filled with sand tamped in dry or puddled into place. The top of the compacted base should be parallel with the intended finished surface and at a distance from it depending upon the character of the surface. For a topping of stone screenings, this distance should be not less than 1 inch; for an asphalt surface, not less than 1½ inches; for brick, not less than the thickness of the brick plus ½-inch sand cushion; for concrete, not less than 4 inches. The filling material for first-class filled platforms should be durable.

Unpaved Surfaces

The surface of unpaved filled platforms should be of granular material that will not become muddy when wet. Slag, cinders, shells, stone screenings, etc., have been used. The surface should be compacted by rolling and/or tamping and crowned or sloped for drainage. An application of stone screenings and stone dust, watered and rolled, is common practice. Surface coatings of oil assist laying dust but are objectionable because of tracking into station and cars. A thin coating of stone screenings and asphalt binder makes a good and inexpensive surface.

Wood Surface

The thickness of the planks and the spacing of the sleepers or joints should be such that the deflection between supports would be very small, even under the heaviest concentrations of load. An air space should be provided under the surface and between the individual planks or boards. A wood surface resting directly on the fill with embedded nailing strips is not recommended. Tongued and grooved material is not suitable for an outside platform surface even though it be covered by a canopy. The boards or planks should be laid parallel with the traffic. For exclusive passenger service or for very little trucking, the surface may be laid transverse to the lines of travel.

Concrete Surface

If heavy truck traffic is to be carried, something more stable than a compacted fill must be provided or the surface itself must have load distributing power. An economical way to obtain the required strength is to place and finish a concrete slab not less than 5 inches thick on the compacted base.

The use of so-called hardeners or densifiers in a concrete wearing surface has some value. Proper materials, proportions, workmanship and *curing* are necessary to guarantee success. Excessive troweling is to be avoided. A surface that is sloppy when finished will not stand the wear expected of it. Neither the base nor the topping of a two-course monolithic job should have any more water in the mix than the minimum necessary for proper compaction and finishing. Only hard, durable aggregate should be used in the topping. Cherty aggregates are hard but not always durable. "Popping" and "pitting" of the surface is due to aggregate that disintegrates when subject to cycles of freezing in a saturated condition. These results are especially to be avoided in platforms subject to heavy trucking.

Proper curing of a concrete wearing surface is of major importance. (See building specifications, Section 22, "Concrete Pavements and Foundations".)

Brick Surface

The base must be firm and unyielding. The sand cushion should be as thin as practicable and thoroughly compacted before the brick surface is laid. Joints should be sand filled after the brick are in place.

Hard burned shale brick are suitable for passenger platforms, but vitrified shale brick should be used for freight trucking platforms.

Asphalt Paving Block Surface

Asphalt block are laid on a concrete base in a fresh mortar bed about ½ inch thick (see building specifications, Section 25-A, "Asphalt Block Pavements").

Asphalt Macadam Surface

Asphalt macadam surfaces on filled platforms should conform, in general, to building specifications, Section 26-B, "Asphalt Macadam Pavements", except that the base

course may be 4 inches thick instead of 6 inches, and the wearing course 1½ inches thick for passenger platforms.

Sheet Asphalt Surface

The melting point, penetration and other properties of asphalt for platform surfaces should conform with the requirements found best suited to the particular climate in which the asphalt is laid.

Asphalt surfaces should preferably be laid on a concrete base for freight platforms, but for passenger platforms and light traffic freight platforms a well compacted stone ballast base or a penetration asphalt and stone base on a settled and firm subgrade may be used. The thickness of the asphalt wearing surface should be not less than ¾ inch.

High Platforms

High platforms such as freight house and transfer platforms not carried on a fill are usually of steel, wood, concrete or a combination thereof. The all wood platform is usually most economical as to first cost, and creosoted lumber should be used for the supporting portion except for temporary locations. The wearing surface may properly be of untreated lumber, especially for freight traffic where wear is most important.

Concrete wearing surfaces should be constructed in accordance with building specifications, Section 22, "Concrete Pavements".

Appendix E

(7) MODERN METHODS OF HEATING SMALL RAILWAY BUILDINGS, SHOWING COMPARATIVE ADVANTAGES OF WARM AIR, HOT WATER, STEAM AND POSSIBLY FAN UNIT SYSTEMS

Eli Christiansen, Chairman, Sub-Committee; A. C. Copland, E. A. Harrison, D. T. Mack, A. H. Morrill.

Considerable information has been accumulated by the Sub-Committee on this subject, and report has been discussed with the General Committee, but as more information is being sought, it is the desire of the Committee that the subject be reassigned for further study.

Appendix F

(8) DESIGN AND CONSTRUCTION OF MODERN FRUIT AND PRODUCE TERMINAL BUILDINGS

E. K. Mentzer, Chairman, Sub-Committee; A. L. Becker, R. E. Mohr, F. R. Rex.

The Sub-Committee has conferred with members of Committee XIV and wish to report progress on this subject, but it is the desire of the Committee that the subject be reassigned for further study.

Appendix G

(9) RELATIVE MERITS OF WOOD AND FIREPROOF ROOF STRUCTURES, WHICH SHOULD INCLUDE WOOD HOLLOW TILE FIREPROOFING, CONCRETE AND CEMENT TILE, ETC.

O. G. Wilbur, Chairman, Sub-Committee; Hugo Filippi, G. A. Belden, F. L. Riley, E. R. Tattershall, Arthur T. Upson.

The Committee reports progress and desires that the subject be reassigned for further study.

Appendix H

(10) SPECIFICATIONS FOR CONCRETE USED IN RAILWAY BUILDINGS

W. T. Dorrance, Chairman, Sub-Committee; A. C. Irwin, F. R. Judd, A. B. Stone.

A report on this subject was presented at the 1931 convention and the specifications published in Bulletin 334, pages 549 to 556 inclusive, with a view to their being published in the Manual at a later date. No suggestions for changes or revision have been received during the year and your Committee now desires to recommend their adoption for publication in the Manual.

for publication in the Manual.

REPORT OF COMMITTEE XXIII—SHOPS AND LOCOMOTIVE TERMINALS

L. P. Kimball, *Chairman;*
C. M. Angel,
F. C. Baluss,
W. H. Barton,
H. G. Dalton,
R. G. Develin,
A. G. Dorland,
E. A. Dougherty,
Benjamin Elkind,
T. H. Gardner,
C. E. Harris,
A. T. Hawk,
A. S. Kent,
E. E. Kimball,
L. H. Laffoley,
H. C. Lorenz,
J. S. McBride,
W. S. McFetridge,
W. A. McGee,
J. M. Metcalf, *Vice-Chairman;*
F. E. Morrow,
B. M. Murdock,
E. S. Pennebaker,
H. W. Pinkerton,
V. B. W. Poulsen,
W. A. Radspinner,
E. H. Roth,
John Schofield,
J. R. Sexton,
H. D. Sheets,
S. E. Shoup,
L. K. Sillcox,
H. L. Smith,
H. W. Williams,
D. E. Woozley,
G. I. Wright,
M. J. T. Zeeman,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) General layouts and design of typical locomotive repair shops collaborating with appropriate committees of Division V—Mechanical, A.R.A..(Appendix B).

(3) Adapting the general layouts and design of car shops for inspecting and repairing multiple unit electric cars, collaborating with appropriate committees of Division V—Mechanical, A.R.A. (Appendix C).

(4) Adapting the design of engine houses and the general layouts and design of typical locomotive repair shops for the inspection and repair of electric locomotives, collaborating with appropriate committees of Division V—Mechanical, A.R.A. (Appendix D).

(6) Modernization of engine terminals to eliminate use of steam power plants for other than heating purposes (Appendix E).

(8) Design of inspection pit (Appendix F).

(9) Engine terminal layout (a) steam locomotives, (b) electric locomotives (Appendix G).

Progress is also reported on the following subjects:

(5) Welding equipment installations as applied to shops and locomotive terminals.

(7) Firing up stations for locomotives.

Action Recommended

1. That the reports in Appendices B, C, D and E be accepted as information.
2. That the conclusions of the reports in Appendices A, F and G be accepted for inclusion in the Manual.

Respectfully submitted,

The Committee on Shops and Locomotive Terminals,
L. P. Kimball, *Chairman.*

Bulletin 343, January, 1932.

Appendix A

(1) REVISION OF MANUAL

F. E. Morrow, Chairman, Sub-Committee; A. T. Hawk, L. P. Kimball, J. M. Metcalf.

The Committee recommends the following changes in the 1929 edition of the Manual. These changes are under the general subjects of:

Engine House Design, and
Store Houses for Shops and Locomotive Terminals.

Engine House Design

(a) Change paragraph (a) under Turntable (page 1471) to read: "If balanced type turntable is used, it should be long enough to balance the engine when tender is empty. Use of a three-point table removes this necessity and is preferable, where long engines are to be handled."

(b) Change the three paragraphs under Smoke Jacks, beginning on the bottom of page 1472, to read as follows:

"Smoke Jacks should be of the fixed type, the bottom opening not less than 42″ wide and long enough (preferably not less than 12 feet) to receive smoke from the locomotive stack at its limiting positions, due to the shifting of locomotive, so as to bring driving wheels and side rods into proper position for repair and also to avoid unnecessarily close spotting of locomotive. The bottom of the jack should be as low as the locomotives to be handled in the house will allow, usually 16′-6″ at ends and 15′-6″ at sides above top of rail, and it should be furnished with a drip trough. The slope upward to the flue should be uniform. The cross-section area of the flue should be not less than seven square feet. An annular space two inches in width should be provided around the flue for engine house ventilation. Jacks should be constructed of non-combustible materials.

"When the engine house is without a turntable, smoke jacks should be located at each end of each engine space. Smoke jacks are unnecessary in an engine house where direct steaming is used, but for special conditions it may be found desirable to install them over a few stalls to permit housing of live locomotives when necessary. In some locations, due to local conditions, special types of jacks are installed in connection with smoke abatement measures."

(c) Change the two paragraphs under Engine Pits on page 1472 to read as follows:

"Engine pits should extend from a point 10 feet from the inner circle columns to a point 13 feet from the inner face of the outer circle wall. They should have a clear width of not less than 3 feet 9 inches, and a minimum depth below base of rail of 2 feet 6 inches, increasing with the slope of the floor of the pit to at least 3 feet. The floor of the pit should be convex and top of walls should be of such width as to provide proper jacking space, usually about 3 feet. Where direct heating is used, the pit walls may be recessed for radiation. For long pits, drainage may be provided at both ends of pit with high point in middle."

(d) Change section under heading of Windows at top of page 1474 to read as follows:

"(a) The disadvantages of skylights are so much greater than their advantages as to make them undesirable.

"(b) Windows in the outer walls should be made as large as practicable with the largest glass or light area consistent with the strength of the structure. These

windows should be provided, as far as practicable, with a continuous row of pivoted sash along the top of windows. In general, the lower sill should be not more than 4 feet from the floor, and space between window frames and columns or pilasters and girders only that necessary to secure the window frames.

"When doors are provided, they should be glazed with glass panels with wire glass."

(e) Change paragraph under heading Mechanical Handling Devices, bottom of page 1474, to read as follows:

"The common use of electrically propelled and operated industrial tractors, trucks and portable cranes practically eliminates the need of traveling cranes, pit cranes or mono-rails, except, perhaps, in a limited portion of the engine house where considerable shop work is done."

(f) Change the paragraph under Floors, on page 1473 to read:

"The floors should be of permanent construction sloped so as to drain properly. The floor around the outer circle and for the outer bay or outer two bays where trucking is carried on and most of the work is done, may advantageously be constructed of wood blocks, asphalt blocks, or vitrified brick on a concrete base, while the remainder of the floor between pits may for the sake of economy be of concrete."

Store Houses for Shops and Locomotive Terminals

(a) Change paragraph under Arrangement, on page 1483, to read:

"The primary consideration is the economical handling of material. The arrangement should be such as to insure ample natural light, and convenient handling, checking and inventorying of materials, and ease of supervision. The store house floor should be at car floor level. Where not enough store supplies are received or shipped from the store house to justify the construction of the store house floor at car floor level, the cost of construction may be reduced by constructing it at practically the track or ground level with raised platform and ramp for unloading to and from cars. Racks should be so located that the handling of materials will be reduced to a minimum, and so that there will be no dark pockets for the accumulation of rubbish, etc. Main aisles of ample width should be provided to allow for the handling of material by motor truck."

(b) Change the last sentence under Casting Storage, page 1486, to read:

"Platforms should be supported directly on the ground, and if the floor level be elevated it should be on fill between retaining walls."

(c) Change the first sentence under Construction, page 1487, to read:

"Oil houses should be constructed of fire resistive materials, including steelsash with wire glass, and all doors in partition walls strictly fire doors controlled by fusible links."

Appendix B

(2) GENERAL LAYOUTS AND DESIGNS OF TYPICAL LOCOMOTIVE REPAIR SHOPS, COLLABORATING WITH APPROPRIATE COMMITTEE OF DIVISION V—MECHANICAL, A.R.A.

C. E. Harris, Chairman, Sub-Committee; C. M. Angel, E. A. Dougherty, W. S. McFetridge, W. A. McGee, V. B. W. Poulsen, W. A. Radspinner, L. K. Sillcox, H. L. Smith.

A general report on this subject was presented to the Association at the 1929 Convention and was published in Vol. 30, 1929 Proceedings, pages 361 to 378 inclusive. As

then, your Committee still feels that it is not justified in laying down any fixed rules as to the type or size of shop to be recommended as established practice. There are certain fundamentals, however, involved in the design of a Locomotive Repair Shop which are basic, irrespective of the type selected. In connection therewith the data included in the report referred to should prove valuable.

A principle of primal importance, regarding which little information is available on which too much stress cannot be laid, is the preparation, following a decision on the capacity of the shop and the classification of repairs to be undertaken, of a Time Study to determine the machine tool equipment necessary, the area of shop floor space to be allotted to each department, and the estimated number of men required to operate the shop. Your Committee believes that an example of what has been done in this respect should be of interest to the members of the Association, and has procured certain data relative thereto, which is herewith presented for the first time. As far as this Committee has been able to determine, the first Time Study of this nature was made in 1907, and used to determine the machine tool requirements for the development of the Locomotive Repair Shop of the Delaware, Lackawanna & Western Railroad at Scranton, Pa. An outline of this study is contained in the Locomotive Dictionary of 1909, and also appeared in subsequent issues, the last being that of 1925. A similar time study, expanded to include a schedule system of locomotive repairs, was used in 1915 in the development of the plans for the repair shop of the Seaboard Air Line Railroad at Portsmouth, Va. The Chesapeake & Ohio Railroad has recently completed a locomotive repair shop at Huntington, West Virginia, which was designed from the determinations resulting from a time study which included all machine tool and erecting shop operations. This time study not only determined the number of machine tools necessary and the floor space required to accommodate them, but also the approximate number of men needed to operate the shop to obtain the output desired. In order that complete co-ordination of the work in all departments should be accomplished, a shop schedule and routing system was developed.

The new locomotive shop at Huntington was designed to provide a maximum output of locomotives receiving heavy classified repairs with the least possible detention from service, and at a minimum expenditure of labor, by taking full advantage of the principles of mass production and the straight line movement of materials, following in general the methods employed by the more progressive automobile manufacturers wherever practicable to apply them to locomotive repair work. Complete detail time studies were first made to determine the number of machine operations and the time required for each necessary for the repairing of a given number of locomotives per month. These studies determined the number, size and capacity of the machine tools necessary to produce a balanced shop operation for all of the several departments comprising the locomotive shop. Machine tools were then grouped in departments in a manner that would permit a proper sequence of operations for the efficient handling of parts and use of labor.

The maximum capacity of the shop at Huntington was estimated to be 50 general repairs per month, of the following classes:

MALLET LOCOMOTIVES

3—to receive Class 2 repairs (New firebox and general repairs to machinery).
14—to receive Class 3 repairs (General repairs to machinery).

—

17—Mallets.

OTHER TYPE LOCOMOTIVES

6—to receive Class 2 repairs (New firebox and general repairs to machinery).
27—to receive Class 3 repairs (General repairs to machinery).

—

33—Other Locomotives.

Total 50—Class 2 and 3 repairs per month.

Shop Schedules

The coordination of the work of all departments at Huntington is accomplished by means of a shop schedule and routing system, the operation of which resembles a train dispatcher's sheet. A large master sheet contains the dates of completion of about 150 major items of repair work for each locomotive undergoing repairs, so operated as to inform all supervisors when their work is to be completed. The master schedules for the different classes of repairs are so timed that there is a constant flow of finished materials to the erecting shop. The net results of this system are a minimum detention of the locomotive while undergoing repairs and an orderly procedure of the work provided by a system of two daily reports that informs all concerned of the operations due to be completed each day, the operations late in completion to date, and the cause and responsibility for the delays. To begin operations in the new shop certain maximum schedules will apply, but it is anticipated that they will be shortened or adjusted as actual operating conditions in the shop indicate changes to be desirable or necessary.

The initial schedules for the 50 general repairs desired per month are as follows:

AVERAGE SCHEDULE—DAYS IN SHOP

Average Days—Per Engine

Engines	*On Inbound Progressive Positions*	*On Heavy Repair Positions*	*On Outbound Progressive Positions*	*Days in Shop per Engine*	*Total Days in Shop All Engines*
3 Mallets Class 2 (New Firebox)	3½	16½	5	25	75
14 Mallets Class 3 (Gen'l. Repairs)	2½	12½	5	20	280
17 Mallets					Total 355
6 Other Locos. Cl. 2 (New Firebox) ...	3½	14½	5	23	138
27 Other Locos. Cl. 3 (Gen'l. Repairs) ...	2½	8½	5	16	432
33 Other Locomotives					Total 570
50 Locomotives					Total days in shop 925

The average number of days of 8 hours each required per locomotive in the above schedule is 18.5 days. This figure for the classes of repairs under consideration at Huntington Shops is considered to be conservative for that shop. It is assumed that an average month contains 25 working days of 8 hours each, or a total of 200 hours per month.

Then: 925 days divided by 25 working days per month equal 37 repair positions required to give the 50 classified repairs per month.

The new shop at Huntington has positions to accommodate 37 locomotive undergoing repairs at one time.

Capacity of Shop

To determine the capacity or size of a locomotive repair shop with respect to the number of repair positions to be provided on any particular basis, the following formula can be utilized:

Let L = Desired output of repaired locomotives per month.
T = Average number of days required for repairs, per locomotive.
D = Average number of days of 8 hours each in month.
P = Number of repair positions in shop.

Then $L = \frac{P \times D}{T}$ and $P = \frac{L \times T}{D}$

The maximum number of locomotives, however, that can be given general repairs per month in any size shop will depend upon the number of working days each locomotive will require for its repairs.

The function T in the above formula, 18.5 days in the case of the Huntington Shops, is dependent upon the classification of repairs to be undertaken and on the facilities provided for making the repairs.

When turning out the maximum output of 50 locomotives per month at Huntington Shops from 37 repair positions, there will be one locomotive enter and one locomotive leave the shop every four hours, which is indicative of the precision with which the departments and divisions of this shop must function.

Machine Tool Equipment

To turn out 50 classified repairs per month at Huntington, of the types of locomotives described, means that working 8 hours per day for 25 days per month, or 200 hours per month, 4 hours is the unit of time for the completion of each major operation on an average engine set of parts. Sufficient equipment has been provided to accomplish this result. The assembly of machine tools into groups for machine operations in the locomotive Machine Shop Department has been in the following principal groups:

Group 1—Driving Wheels, Trailer Truck Wheels, Axles and Crank Pins.
2—Driving Boxes.
3—Shoes and Wedges.
4—Frames, Pilot Beams, Deck Castings, etc.
5—Cylinder Heads, Cylinder Bushings, Steam Chest Valves, Bushings and Covers.
6—Pistons and Rods, Cross Heads and Guides.
7—Main and Side Rods.
8—Valve Motion, except Power Reverse Gear Cylinders and Reverse Levers.
9—Spring and Brake Rigging.
10—Engine Trucks, Trailer Trucks, Boosters and Stokers.
11—Steam and Exhaust Pipes, Superheaters, Feed Water Heater Drums.
12—Brass Work, Cab and Boiler Mountings, Air Brakes, except Air Pumps.
13—Turret Lathe Work.
14—Air Pumps, Boiler Feed Pumps and Pneumatic Devices.
15—Bolts and Pins.
16—Drifting Valves, Intercepting and By-pass Valves, Reverse and Throttle Levers and Cylinder Cock Rigging.
17—Miscellaneous Work—Fitting Binders, Braces, etc.

Your Committee believes that the form used for setting up the studies of machine tool operations for the above principal groups and the information contained in some of them can be of considerable value to one charged with a projected shop in the development of which first cost and cost of operation are of importance, and submit

herewith as information, the make up of the Groups 1 to 5 inclusive. Attention is called to the fact that the total time, per machine hours, appearing on the form sheets includes a 25 per cent allowance for shop order work. The extent to which such provision should be made will be determined by the individual case. It is also to be noted in the studies that in some cases the total time for one machine is more than 200 hours per month allotted time for each machine on the basis of an 8-hour day. In the event that work done on the machine was such that the estimated required time was positive, as in the case of the 90 in. Driving Wheel Lathe, Group 1, an additional machine was provided to take care of the extra hours including shop order requirements. Where the work was such that the estimated figures varied on different locomotives, it was decided, rather than to install an extra machine, to work the machine overtime when necessary. Such a case is the 96 in. Vertical Boring Mill of Group 1.

The Time Study developed that to handle shoes, wedges and driving boxes with the standard machine tools usually provided for the purpose, a large number of such tools would be required occupying floor space that might be utilized for other purposes, should it be possible to obtain special machines for these groups. Through the cooperation of the machine tool manufacturers special machine tools were developed that have proven very satisfactory in their operation and the area required for the groups was accordingly very materially reduced. The portion of the Time Study of Machine Tool Operations is submitted as Exhibit A.

In addition to the foregoing are included the following:

Exhibit B—Statement of estimated forces to operate the Locomotive Shop at Huntington, W. Va.
Exhibit C—General Arrangement of Shop Bays.
Exhibit D—Yard Plan.
Exhibit E—Airplane photograph of Huntington Shops.

Exhibit B is presented as information. It represents the estimated requirements for a shop which has been developed for mass production in locomotive repair work. When the shop is finally placed in full operation and the actual man power requirements develop, it is anticipated that the schedule as presented may be altered materially. Exhibit B is not presented as a schedule of the actual number of men required to operate a locomotive repair shop having a capacity to turn out 50 locomotives per month. To do so would be misleading, as the force required to operate a particular size shop is dependent upon so many variables, as for instance, the geographical location of the shop has a considerable bearing on the organization required for its operation. It is to be expected also that improvements in machines and methods will influence the time on various machine tool operations.

Exhibit C is presented as information. It shows the general arrangement of the locomotive repair shop at Huntington, and the relation of the various shop divisions and departments to each other.

Exhibit A

THE CHESAPEAKE AND OHIO RAILWAY COMPANY
Huntington, W. Va.

TIME STUDY OF MACHINE TOOL OPERATIONS FOR LOCOMOTIVE REPAIR SHOP TO PERFORM CLASS 2 AND 3 REPAIRS ON 50 LOCOMOTIVES PER MONTH

GROUP NO. 1

Driving Wheels, Engine and Trailer Truck Wheels, Axles and Crank Pins

	No. of Parts	*Per-cent of parts Rep'd.*	*No. of Parts Rep'd. or Renewed*	*Time for each pt. Hrs. Min.*	*Total Time for parts Hrs. Min.*	*Total Time per Mach. Hrs.*
1—96 in. Vertical Boring Mill						
Bore, turn and face, new driving wheel centers	500	10	50	4 00	200 00	
Bore, turn and face, trailer wheel centers	100	5	5	2 00	10 00	
Bore, turn and face, arch rings	50	5	2.5	2 30	6 15	
Turn, smoke box fronts	50	5	2.5	1 00	2 30	273.5
1—72 in. Radial Drill Press						
Drill and tap, counterbalances	500	10	50	1 00	50 00	
Drill, crank pins (main)	134	20	26.8	0 30	13 24	
Drill, crank pins (fr. and interm.)	200	20	40	1 00	40 00	
Drill, crank pins (back)	98	20	19.6	0 10	3 16	
Drill and tap, driving wheel centers for hub liners	500	10	50	1 00	50 00	
Drill and tap, trailer wheel centers for hub liners	100	5	5	1 00	5 00	202.1
1—24 in. Morton Keyway Cutter						
Cut, keyway in driving wheel centers	500	10	50	0 20	16 42	
Cut, keyway in eccentric arms	100	10	10	0 18	3 00	24.6
1—90 in. Double Wheel Quartering and Crank Pin Turning Machine						
Bore, crank pin holes in new wheel centers, and true up, old pins	250pr.	20	50 prs.	0 42	35 00	
True up, crank pin holes in old wheel centers, and true up, old pins	250pr.	80	200 prs.	0 42	140 00	218.8
2—90 in. Driving Wheel Lathes						
Turn, driving wheel tires	250pr.	75	187.5prs.	1 00	187 30	
Turn, driving wheel tires	250pr.	25	62.5prs.	1 00	62 30	
Turn, trailer wheel tires	50pr.	100	50 prs.	0 35	29 10	174.5
1—90 in. Journal Turning Lathe						
1—90 in. Combination Journal Turning Lathe						
True up and roll, journals, and face, hub liners and driving wheels	250pr.	75	187.5prs.	1 30	281 15	175.8
1—55 in. Combination Journal Truing and Axle Turning Lathe						
True up and roll, journals, and face, hub liners on trailer wheels	50pr.	75	37.5prs.	1 30	56 15	
True up and roll, journals, and face, hub liners on engine truck wheels	50pr.	75	37.5prs.	1 15	46 53	
True up, old trailer axle journals	50pr.	50	25	0 30	12 30	
True up, old tender truck axle journals	250	50	125	0 30	62 30	222.7

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
1—Locomotive Axle Keyseating Milling Machine						
Cut, keyway in driving axles	522	25	130.5	0 30	65 15	81.6
2—24 in. × 5 ft. 6 in. Engine Lathes						
Turn, driving axles	250	15	37.5	5 00	187 30	234.4
1—28 in × 8 ft. 4½ in. Double Head Axle Lathe						
Turn, driving axles	250	10	25	5 00	125 00	
Turn, trailer truck axles	50	25	12.5	4 00	50 00	218.8
2—24 in × 5 ft. 6 in. Engine Lathes						
Turn and fit, main crank pins	134	20	26.8	4 00	107.12	
Fit crank pins, front and intermed.....	200	20	40	1 00	40 00	
Thread and fit, back crank pins	98	20	19.6	1 15	24 30	107.3
1—24 in. Shaper						
Shape, crank pin keys	134	20	26.8	0 40	17 52	
Shape, driving axle keys	500	25	125	0 40	83 20	
Shape, expansion plugs	100	30	30	0 30	15 00	145.3
1—600 Ton Driving Wheel Press						
Press off, driving wheels	250pr.	35	87.5prs.	0 30	43 45	
Press on, driving wheels	250pr.	35	87.5prs.	0 30	43 45	
Press off, trailer wheels	50pr.	30	15 prs.	0 25	6 15	
Press on, trailer wheels	50pr.	30	15 prs.	0 25	6 15	
Press out, crank pins	500	70	350	0 18	105 00	
Press in, crank pins	500	70	350	0 18	105 00	
Press off, booster axle gears	6	34	2	0 30	1 00	
Press on, booster axle gears	6	34	2	0 30	1 00	390.0
1—5 ft. × 7 ft. Tire Heating Furnace.						
1—Counter Balancing Stand.						
1—Lead Pot and Furnace.						
2—Portable Electric Welding Outfits.						
1—Double Dry Grinder.						
Total number of machine hours for Group No. 1						2927.0

GROUP No. 2

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
Driving Boxes						
1—36 in. × 16 ft. 3-Head Driving Box Milling Machine						
Mill, inside faces, edges and shoe and wedge faces—one set up (new driving boxes)	500	10	50	0 45	37 30	
Mill, shoe and wedge faces of (old and new) driving boxes after brass liners have been poured	500	100	500	0 15	125 00	203.1
1—48 in. × 16 ft. Planer						
Dovetail, shoe and wedge face on new driving boxes	500	10	50	1 00	50 00	62.5
1—42 in. Vertical Turret Lathe						
Face, new driving boxes, and dovetail for hub liners	500	10	50	1 30	75 00	
Cut off, hub liners, and true, dovetail on old driving boxes	500	90	450	0 20	150 00	281.3

Group No. 2

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
2—54 in. Driving Box Boring and Facing Machines						
Bore and face, hub plates on old and new driving boxes	500	100	500	0 25	208 20	130.2
1—30 in. Driving Box Slotter						
Slot, driving box crown brass and cellar faces (new boxes)	500	10	50	0 40	33 20	
True up, crown brass face of old boxes	500	90	450	0 20	150 00	229.2
2—30 in. Draw Cut Shapers						
Plane, driving box crown brasses, new and old driving boxes	500	100	500	0 48	400 00	250.0
1—36 in. Draw Cut Shaper						
Shape, driving box cellars, (old and new)	500	20	100	0 30	50 00	62.5
3—4 ft. Radial Drills with 6 ft. Arm						
Drill and tap, new driving boxes for hub liners and shoe and wedge liner bolts	500	10	50	1 00	50 00	
Drill and tap, old driving boxes for hub liners and shoe and wedge liner bolts	500	60	300	0 30	150 00	
Drill and ream, driving boxes for crown brass plugs—new boxes	500	10	50	0 20	16 40	
Drill and ream, driving boxes for crown brass plugs—old boxes	500	90	450	0 10	75 00	
Drill, driving boxes and cellars, and tap, for bolts—new boxes	500	10	50	0 20	16 40	
Drill, driving boxes and cellars for bolts—old boxes	500	90	450	0 10	75 00	
Drill, oil holes in new driving boxes	500	10	50	0 20	16 40	
Drill, oil holes in old driving boxes	500	90	450	0 15	112 30	213.5
2—100 Ton Hydraulic Vertical Presses						
Press out, crown brasses	500	100	500	0 05	41 40	52.1
Press in, crown brasses	500	100	500	0 05	41 40	52.1
1—1000-lb. Capacity Simplex Brass Furnace						
For casting, hub liners and shoe and wedge liners on driving boxes	500	100	500	0 30	250 00	312.5
1—4 ft. X 6 ft. Face Plate						
Laying off, driving boxes, chipping, etc.						
Total number of machine hours for Group No. 2						2656.2

Group No. 3

Shoes and Wedges

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
1—36 in. X 16 ft. Horizontal Milling Machine						
Mill, shoes and wedges on inside and outside	1000	75	750	0 09	112 30	140.6
1—24 in. Vertical Lever Drill Press						
Drill, old shoes and wedges for liners	1000	25	250	0 06	25 00	31.3
1—38 in. X 14 ft. Planer						
Plane, shoes and wedges to line	1000	75	750	0 15	187 30	234.4

GROUP NO. 3

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
1—32 in. Crank Planer						
Plane, shoes and wedges to line	1000	25	250	0 25	104 10	130.2
Total number of machine hours for Group No. 3						536.5

GROUP NO. 4

Frames, Pilot Beams, Deck and Draw Castings
Adjacent to Group No. 4 is Group No. 10
Engine and Trailer Trucks, Boosters and Stokers

The machine tools for both Group No. 4 and Group No. 10 have been scheduled under Group No. 4 and the equipment is common to both Groups. In addition to the work for Groups No. 4 and No. 10 the machine tools are also utilized for machine work on miscellaneous parts, grates and ash pan rigging, and large castings for Group No. 23 Boiler and Tank Shop.

1—48 in. × 14 ft. Planer						
Plane, frame rails	100	5	5	6 00	30 00	
Plane, frame filling castings	366	5	18.3	2 00	36 36	
Plane, frame pedestal caps	500	5	25	1 00	25 00	
Plane, centering device brackets	50	2	1	1 30	1 30	
Plane, bearing plate (brass)	25	50	12.5	2 00	25 00	
Plane, bearer wearing plates (steel) new	42	2	.8	3 00	2 24	
Plane, bearer wearing plates (steel) old	42	10	4.2	2 00	8 24	
Plane, floating device spring seat wear plates	17	2	.3	2 00	0 36	
Plane, floating device castings	17	2	.3	1 30	0 27	
Plane, floating device boiler bearings..	17	2	.3	2 00	0 36	
Plane, main boiler bearing plates (brass)	8	50	4	2 00	8 00	
Plane, bottom hinge draw castings	17	15	2.6	13 00	33 48	
Plane, draw gear hinges	17	15	2.6	3 00	7 48	
Plane, bumper castings	50	3	1.5	3 00	4 30	
Plane, pilot knee castings	100	10	10	1 00	10 00	
Plane, steam pipe supports	17	4	.7	2 00	1 24	245.1
2—6 ft. Radial Drill Presses and Drill Car						
Drill, frame rails	100	5	5	4 00	20 00	
Drill, frame filling castings	366	5	18.3	1 30	27 27	
Drill, guide yoke and frame cross-ties..	67	5	3.4	5 00	17 00	
Drill, frame cross-ties	116	3	3.5	7 00	24 30	
Drill, cross-tie radius bars	50	5	2.5	1 00	2 30	
Drill, frame cradles	50	1	.5	15 00	7 30	
Drill and tap, frame pedestal caps—new	500	5	25	1 00	25 00	
Drill and tap, centering device boiler bearings	25	2	.5	2 00	1 00	
Drill, centering device boiler bearing plates (brass)	25	50	12.5	0 30	6 15	
Drill, centering device brackets	50	2	1	1 00	1 00	
Drill, bearer wearing plates (steel) new and old	42	12	5	0 20	1 40	
Drill, centering device spring seat plates	50	5	2.5	0 10	0 25	
Drill, centering device spring rods	50	5	2.5	0 10	0 25	
Drill and tap, floating device spring seat wearing plates	17	2	.3	0 30	0 09	
Drill, floating device castings	17	2	.3	0 30	0 09	
Drill, floating device hangers	68	5	3.4	0 20	1 08	
Drill, main boiler bearings	8	2	.2	1 00	0 12	

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
GROUP No. 4						
Drill, main boiler bearing wearing plates (brass)	8	50	4	0 30	2 00	
Drill, bottom hinge-draw castings (4 holes) and other holes drilled in place	17	15	2.6	0 42	1 49	
Drill and tap, draw gear hinges	17	15	2.6	1 00	2 36	
Drill, draw castings hinge shafts	17	10	1.7	0 20	0 34	
Drill, bumper castings	50	3	1.5	3 30	5 15	
Drill and tap, bumper beam brackets	50	2	1	8 00	8 00	
Drill, pilots complete	50	2	1	8 00	8 00	
Drill, steam pipe supports	17	4	.7	1 00	0 42	
1—6 ft. Radial Drill Press						
GROUP No. 10						
Drill, engine truck frames	50	2	1	3 00	3 00	
Drill, engine truck pedestals	200	10	20	0 12	4 00	
Drill, engine truck pedestal binders	100	10	10	0 06	1 00	
Drill and tap, engine truck boxes	100	10	10	0 30	5 00	
Drill, brass hub liners for engine truck boxes	100	100	100	0 12	20 00	
Drill, engine truck bolsters	50	5	2.5	1 30	3 45	
Drill, engine truck swing bolster hangers	132	10	13.2	0 15	3 18	
Bore and drill, radius bars	50	10	5	1 30	7 30	
Drill, radius bar braces	100	10	10	0 12	2 00	
Drill and bore, trailer truck radius bar ends	50	10	5	2 00	10 00	
Drill, trailer truck side pieces	100	5	5	0 30	2 30	
Drill, trailer truck frame back end	50	5	2.5	1 30	3 45	
Drill, trailer truck boxes	100	10	10	1 30	15 00	
Drill, trailer truck box hub plates (brass)	100	100	100	0 18	30 00	
Bore and drill, trailer truck spring yokes	100	5	5	4 00	20 00	
Drill, trailer truck spring seats	100	5	5	0 10	0 50	
Drill, trailer truck side bearings	100	5	5	0 40	3 20	
Drill, trailer truck side bearing blocks	100	5	5	0 15	1 15	
Drill, trailer truck adjusting spring rods	100	5	5	0 06	0 30	
Drill, feedwater heater brackets	30	5	1.5	0 45	1 08	
GROUP No. 23						
Drill, smoke stacks	50	5	2.5	0 30	1 15	
Drill, smoke stack extensions	50	5	2.5	0 30	1 15	
Drill, smoke box damper shaft bearings	28	5	1.4	0 18	0 25	
Drill, feedwater pump brackets	56	5	2.8	1 00	2 48	
Drill, smoke box front doors	50	5	2.5	0 30	1 15	
Drill, air reservoir brackets	100	5	5	0 30	2 30	
Bore and drill, feedwater pipe clamps	56	5	2.8	0 30	1 24	
Drill, spark hoppers	50	5	2.5	0 20	0 50	
Bore and drill, injector pipe supports	50	5	2.5	0 30	1 15	
Drill, ash pan slides	100	10	10	0 20	3 20	
Drill, grate rigging details	500	10	50	0 15	12 30	
Drill, ash pan rigging details	300	10	30	0 15	7 30	
Drill dome caps	50	5	2.5	1 00	2 30	
Drill, fire door castings	50	10	5	0 18	1 30	143.1
48 in. x 18 ft. Open Side Planer						
GROUP No. 4						
Plane, guide yoke and frame cross-ties	67	5	3.4	10 00	34 00	
Plane, frame cross-ties	116	3	3.5	10 00	35 00	

Group No. 4	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
Plane, frame cradles	50	1	.5	20 00	10 00	
Plane, centering device boiler bearings	25	2	.5	5 00	2 30	
Plane, main boiler bearings	8	2	.2	5 00	1 00	
Plane, bumper beam brackets	50	2	1	15 00	15 00	
Plane, smoke arch rings	50	5	2.5	10 00	25 00	
Group No. 10						
Plane, engine truck frames	50	2	1	4 30	4 30	
Plane, engine truck pedestals	200	10	20	0 42	14 00	
Plane, engine truck bolsters	50	5	2.5	1 30	3 45	
Plane, radius bars	50	10	5	1 00	5 00	
Plane, trailer truck radius bars	50	10	5	1 00	5 00	
Plane, trailer truck frames (back end)	50	5	2.5	1 30	3 45	
Plane, trailer truck boxes	100	10	10	3 00	30 00	
Plane, trailer truck side bearings	100	5	5	1 30	7 30	
Plane, feedwater heater brackets	30	5	1.5	2 00	3 00	
Group No. 23						
Plane, ash pan hopper castings	100	10	10	0 42	7 00	
Plane, ash pan slides	100	10	10	1 00	10 00	270.0
18 in. Slotter						
Group No. 4						
Slot, engine truck boxes	100	10	10	2 00	20 00	
Slot, trailer truck boxes	100	10	10	2 00	20 00	
Slot, trailer truck spring yokes	100	5	5	1 30	7 30	
Slot, trailer truck spring seats	100	5	5	1 00	5 00	
Group No. 10						
Slot, frame rails	100	5	5	3 00	15 00	
Slot, frame fitting castings	366	5	18.3	3 00	54 54	
Slot, frame cross-ties	50	3	1.5	3 00	4 30	
Slot, crosstie radius bars	50	5	2.5	2 00	5 00	
Slot, frame pedestal caps (new)	500	5	25	2 00	50 00	
Slot, frame pedestal caps (old)	500	5	25	1 00	25 00	
Slot, bumper castings	50	3	1.5	2 00	3 00	
Group No. 23						
Slot, grate bearing bars	150	10	15	2 00	30 00	
Slot, grate rigging details	50	10	5	1 00	5 00	306.1
24 in. Shaper						
Group No. 4						
Shape, frame keys	336	10	33.6	0 30	16 48	
Shape, floating device hangers	68	5	3.4	0 20	1 08	
Shape, waist bearer clamps	68	5	3.4	1 00	3 24	
Group No. 10						
Shape, engine truck pedestal binders	100	10	10	0 30	5 00	
Shape, engine truck boxes	100	10	10	2 00	20 00	
Shape, engine truck cellars	100	10	10	0 30	5 00	
Shape, radius bar braces	100	10	10	0 30	5 00	
Shape, trailer truck side pieces	100	5	5	1 00	5 00	
Shape, trailer truck box covers	100	5	5	0 30	2 30	
Shape, trailer truck box cellars	100	10	10	0 30	5 00	
Shape, trailer truck spring hinge castings	200	5	10	0 15	2 30	
Shape, trailer truck side bearing blocks	100	5	5	0 15	1 15	
Shape, trailer truck adjusting spring rods	100	5	5	0 30	2 30	

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
GROUP No. 23						
Shape, feedwater pipe clamps	56	5	2.8	0 30	1 24	
Shape, injector pipe supports	50	5	2.5	0 30	1 15	97.2
42 in. Vertical Turret Lathe						
GROUP No. 10						
Face, engine truck boxes (new)	100	10	10	0 40	6 40	
Face, engine truck boxes (old)	100	90	90	0 20	30 00	
Bore, engine truck cellars	100	10	10	0 25	4 10	
Bore, engine truck bolsters	50	5	2.5	1 00	2 30	
Machine, trailer truck box hub plates (brass)	100	100	100	0 30	50 00	
GROUP No. 23						
Face, smoke box front doors	50	5	2.5	0 30	1 15	
Turn, dome caps	50	5	2.5	2 00	5 00	
Bore and turn, auxiliary domes	50	5	2.5	1 30	3 45	129.2
20 in. Vertical Drill Press						
GROUP No. 10						
Drill, engine truck cellars	100	10	10	0 18	3 00	
Drill, swing bolster hanger bushings ...	68	100	68	0 02	2 16	
Drill, swing bolster hanger pins	204	100	204	0 02	6 48	
Drill, trailer truck box covers	100	5	5	0 15	1 15	
Drill, trailer truck box cellars	100	10	10	0 12	2 00	
Drill, trailer truck spring hinges castings	200	5	10	0 06	1 00	
GROUP No. 23						
Drill, ash pan hopper castings	100	10	10	1 00	10 00	32.5
24 in. x 6 ft. Engine Lathe						
GROUP No. 4						
Turn and bore, frame filling casting bushings	268	100	268	0 12	53 36	
Turn, frame cross-tie dowels	100	20	20	0 20	6 40	
Bore and face, centering device spring seat plates	50	5	2.5	1 00	2 30	
Face, centering device spring seats	50	5	2.5	0 30	1 15	
Turn, centering device spring seat pins	50	50	25	0 20	8 20	
Bore and turn, centering device spring rod bushings	50	100	50	0 10	8 20	
Bore and turn, floating device hanger casting bushings	204	75	153	0 12	30 36	
Bore and turn, hinge casting bushings..	85	100	85	1 00	85 00	
Turn, draw casting hinge shaft	17	10	1.7	2 30	4 15	
Turn, draw casting hinge pins	17	20	3.4	1 00	3 24	
Bore and turn, bumper beam bracket bushings	50	2	1	1 00	1 00	
22 in. x 12 ft. 1 in. Engine Lathe						
GROUP No. 10						
Turn and bore, swing bolster hanger bushings	68	100	68	0 15	17 00	
Turn, center guide pins	50	20	10	1 00	10 00	
Turn, king bolts	17	30	5.1	2 00	10 12	
Turn, trailer truck spring yoke seats....	100	5	5	1 00	5 00	
Turn and face, trailer truck spring seats	100	5	5	1 00	5 00	
Turn, stoker screws	50	100	50	1 00	50 00	189.4

	No. of Parts	Per-cent of parts Rep'd	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
66 in. Horizontal Boring Mill						
GROUP No. 4						
Bore, frame fitting castings	134	5	6.7	1 00	6 42	
Bore, frame cradles	50	1	.5	15 00	7 30	
Bore, floating device castings	17	2	.3	2 00	0 36	
Bore, floating device boiler bearings ...	17	2	.3	2 00	0 36	
Bore, bottom hinge draw castings	17	15	2.6	8 00	20 48	
Bore, draw gear hinges	17	15	2.6	3 00	7 48	
Bore, bumper beam brackets	50	2	1	8 00	8 00	
Bore, steam pipe supports	17	4	.7	2 00	1 24	
Bore and face, smoke stacks	50	5	2.5	1 30	3 45	
Bore and face, smoke stack extensions..	50	5	2.5	1 30	3 45	76.1
Total number of machine hours for Group No. 4						1964.3

GROUP No. 5

Cylinder Heads and Bushings, Steam Chest Valves, Bushings and Covers
Adjacent to Group No. 5 are:

Group No. 6. Pistons and Rods, Cross Heads and Guides
Group No. 9. Spring and Brake Rigging
Group No. 16. Drifting Valves, Intercepting and By-Pass Valves
Reverse and Throttle Levers and Cylinder Cock Rigging

The machine tools in Group No. 5 are also utilized for machine work on miscellaneous items for these Groups in addition to the machine tools assigned to these Groups.

	No. of Parts	Per-cent of parts Rep'd	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
54 in. Special Double Head Cylinder Bushing Boring Mill						
GROUP No. 5.						
Bore, turn and cut off, cylinder bushings	134	35	46.9	7 00	328 18	410.4
32 in. Crank Planer						
GROUP No. 5						
Plane, back piston valve cylinder heads	114	5	5.7	1 30	8 33	
Plane, side valve strips	80	100	80	0 42	56 00	
Plane, old valves	20	100	20	1 00	20 00	
Plane, balance plates (new)	20	10	2	2 00	4 00	
Plane, balance plates (old)	20	90	18	1 00	18 00	
Plane, false valve seats (new)	20	10	2	2 00	4 00	
Plane, false valve seats (old)	20	90	18	1 00	18 00	
Plane, slide valve yokes	20	10	2	2 00	4 00	
GROUP No. 9						
Plane, equalizer fulcrum—front (new).	50	10	5	1 00	5 00	
Plane, transverse equalizers—back (new)	50	10	5	1 00	5 00	
Plane, equalizers	167	10	16.7	1 00	16 42	
Plane, brake fulcrums	134	5	6.7	1 30	10 03	
Plane, brake hanger levers	250	5	12.5	1 00	12 30	
Plane, Dr. Brake cylinder levers........	134	5	6.7	0 30	3 21	
GROUP No. 16						
Plane, throttle cranks	50	5	2.5	0 30	1 15	
Plane, throttle lever latch links	50	5	2.5	0 30	1 15	
Plane, throttle lever brackets	50	5	2.5	1 00	2 30	
Plane, cylinder cook shaft bearings....	50	5	2.5	1 00	2 30	
Plane, throttle lever latch boxes	50	5	2.5	1 00	2 30	
Plane, reverse lever quadrant supports..	50	5	2.5	1 00	2 30	
Plane, reverse lever latch boxes	50	5	2.5	1 00	2 30	
Plane, reverse lever latch links	50	5	2.5	0 30	1 15	
Plane, old reverse gear crossheads	50	10	5	0 15	1 15	253.3

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
1—Portable Piston Valve Cylinder Boring Bar						
1—Portable Boring Bar						
GROUP No. 5						
Bore out, piston valve cylinders after pulling out old bushings	114	35	39.9	2 00	79 48	
True up, old piston valve bushings in place	114	65	74.1	3 00	222 18	151.1
4—Portable Cylinder Boring Bars						
GROUP No. 5						
True up, cylinders after pulling out old bushings	134	35	46.9	5 00	234 30	
True up, old bushings in place	134	65	87.1	6 30	566 09	200.2
Portable Bushing Puller						
GROUP No. 5						
Pull out, old cylinder bushings	134	35	46.9	0 30	23 27	
Pull in, new cylinder bushings	134	35	46.9	0 30	23 27	
Pull out, old piston valve bushings	228	35	79.8	0 15	19 57	
Pull in, new piston valve bushings	228	35	79.8	0 15	19 57	86.8
Portable Valve Seat Facing Machine						
GROUP No. 5						
True up, old slide valve seats on cylinders	20	100	20	2 30	50 00	50
32 in. Vertical Turret Lathe						
GROUP No. 5						
Bore and turn, piston valve cylinder rings	456	100	456	0 15	114 00	
GROUP No. 9						
Bore out, fulcrum castings	134	5	6.7	1 00	6 42	
GROUP No. 16						
Bore and make joint, on throttle box..	50	10	5	2 00	10 00	
Rebore, old throttle boxes and make joints	50	20	10	1 00	10 00	
Machine, intercepting valves	10	10	1	2 00	2 00	178.4
42 in. Vertical Turret Lathe						
GROUP No. 5						
Bore, turn and face, piston valve followers	228	10	22.8	2 00	45 36	
Bore and turn, piston valve bushings..	228	35	79.8	2 00	159 36	256.5
42 in. Vertical Turret Lathe						
GROUP No. 5						
Bore, turn and face, back cylinder heads	134	10	13.4	5 00	67 00	
Bore, turn and face, front cylinder heads	134	10	13.4	1 30	20 06	
Bore, turn and face, front piston valve cylinder heads	114	5	5.7	2 00	11 24	
Bore, turn and face, back piston valve cylinder heads	114	5	5.7	4 00	22 48	151.6
18 in. Slotter						
GROUP No. 5						
Slot, piston valve rings	456	100	456	0 03	22 48	
Slot, slide valve yokes	20	10	2	1 00	2 00	
Cut keyway, in piston valve followers..	228	10	22.8	0 15	5 42	

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
GROUP NO. 6						
Slot keyway, in crossheads for wrist pin dowels	134	10	13.4	0 15	3 21	
GROUP NO. 9						
Slot, engine truck equalizers (new)	50	5	2.5	2 00	5 00	
Slot, engine truck equalizers (old)	50	20	10	2 00	20 00	
Slot, equalizers to trailer truck (new)	100	5	5	1 30	7 30	
Slot, equalizers to trailer truck (old)	100	20	20	1 00	20 00	
Slot, transverse equalizers front (new)	50	5	2.5	2 00	5 00	
Slot, transverse equalizers front (old)	50	20	10	1 00	10 00	
Slot, transverse equalizers, back (new)	50	10	5	1 00	5 00	
Slot, equalizers	497	10	49.7	0 30	24 51	
Slot, spring hangers	200	10	20	1 00	20 00	
Slot, driving spring saddles (new)	500	5	25	1 30	37 30	
Slot, driving spring saddles (old)	500	10	50	0 30	25 00	
Slot, driving brake hanger brackets	134	5	6.7	1 30	10 03	
Slot, driving brake fulcrum brackets	68	5	3.4	1 00	3 24	290.2
GROUP NO. 16						
Slot, throttle lever yokes	50	5	2.5	0 30	1 15	
Slot, throttle lever fulcrums	50	5	2.5	0 20	0 50	
Slot keyway, in throttle cranks	50	5	2.5	0 10	0 25	
Slot, throttle lever connection links	50	5	2.5	1 00	2 30	
No. 5 Milling Machine						
GROUP NO. 5						
Mill, piston valve bushing port holes	228	35	79.8	2 00	159 36	
Mill, port holes in false valve seats	20	10	2	2 30	5 00	
GROUP NO. 16						
Mill, throttle lever quadrants	50	5	2.5	5 00	12 30	
Mill, throttle lever latches	50	5	2.5	0 30	1 15	
Mill, reverse lever quadrants	50	5	2.5	5 00	12 30	
Mill, reverse lever latches	50	5	2.5	0 30	1 15	
Mill, throttle lever fulcrums	50	5	2.5	1 00	2 30	
Mill, throttle lever latch handles	50	5	2.5	0 30	1 15	
Mill, reverse lever latch handles	50	5	2.5	0 18	0 45	
Mill, reverse levers	50	5	2.5	1 00	2 30	249.0
27 in. x 12 ft. 6 in. Engine Lathe						
GROUP NO. 5						
Bore, turn and face, piston valve spools	114	5	5.7	1 30	8 36	
Bore, turn and face, piston valve bull rings	228	20	45.6	1 00	45 36	
Re-turn, piston valve rings	456	100	456	0 05	38 00	
Turn and thread, piston valve stems	114	10	11.4	3 30	39 54	
Face, piston valve stem nuts	228	10	22.8	0 03	1 08	
Machine, stuffing box bushings	134	100	134	0 12	26 48	
Machine, swab cups	134	20	26.8	0 10	4 30	205.7
18 in. x 4 ft. 8 in. Engine Lathe						
GROUP NO. 5						
Turn and bore, valve stem sliding plate rings	134	100	134	0 15	33 30	
Machine, sliding plate half pieces	134	100	134	0 45	100 30	
Machine, valve stem retainer rings	134	50	67	0 20	22 20	
Bore, turn and face, valve stem packing glands	134	5	6.7	0 45	5 00	
Bore, valve stem packing	134	100	134	0 15	33 30	243.5

	No. of Parts	Per-cent of parts Rep'd.	No. of Parts Rep'd. or Renewed	Time for each pt. Hrs. Min.	Total Time for parts Hrs. Min.	Total Time per Mach. Hrs.
42 in. x 14 ft. Planer						
GROUP No. 5						
Plane, slide valves	20	10	2	5 00	10 00	
Plane, slide valve castings	20	10	2	3 00	6 00	
Plane, slide valve covers	20	10	2	1 30	3 00	
Plane, old slide valve covers	20	10	2	0 30	1 00	
Plane, back cylinder heads	134	10	13.4	2 00	26 48	
GROUP No. 6						
Plane, new crossheads	134	5	6.7	2 00	13 24	
Plane, guide yokes	67	5	3.4	3 00	10 12	
Plane, guide yoke extensions	67	5	3.4	3 00	10 12	
Plane, guide yoke brackets	134	5	6.7	3 00	20 06	
GROUP No. 9						
Plane, engine truck equalizers (new) ..	50	5	2.5	2 00	5 00	
Plane, engine truck equalizers (old) ...	50	20	10	2 00	20 00	157.1
12 in. x 36 in. External Grinder						
GROUP No. 5						
Grind, piston valve stems (new)	114	10	11.4	0 45	8 33	
Grind, piston valve stems (old)	114	90	102.6	1 30	153 54	203.1
34 in. Vertical Drill Press						
GROUP No. 5						
Drill and tap, valve stem packing glands	134	10	13.4	0 10	2 14	
Drill, valve stem keys	134	50	67	0 02	2 14	
Drill, piston valve stems	134	10	13.4	0 15	3 21	
Drill and tap, front cylinder heads	134	10	13.4	1 00	13 24	
Drill and tap, back cylinder heads	134	10	13.4	1 30	20 06	
Drill and tap, front piston valve cylinder heads	114	5	5.7	0 30	2 51	
Drill and tap, back piston valve cylinder heads	114	5	5.7	0 48	4 34	
Drill, piston valve spools	114	5	5.7	0 12	1 08	
Drill, piston valve bull rings	228	20	45.6	0 02	1 31	
Drill and tap, steam chest covers	20	10	2	0 30	1 00	
Drill, swab cups	134	20	26.8	0 05	2 14	
Drill, valve stem keys	134	50	67	0 02	2 14	72.1
Total number of machine hours for Group No. 5.............................						3910.7

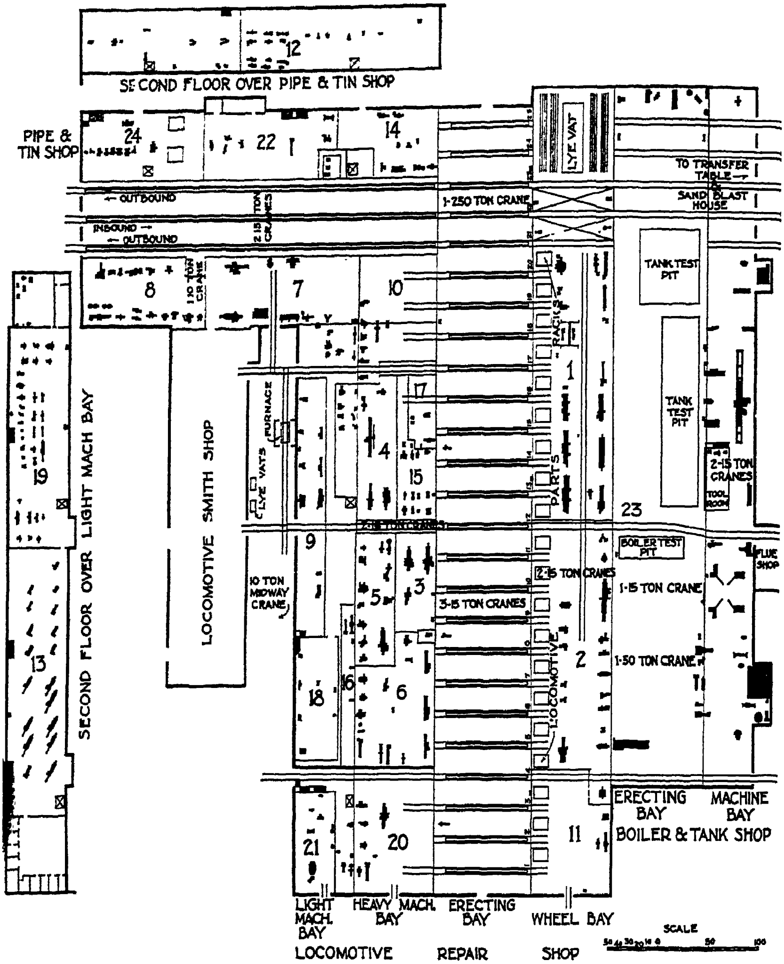
Exhibit B

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

STATEMENT OF ESTIMATED FORCES TO OPERATE LOCOMOTIVE SHOP AT HUNTINGTON, W. VA.

Line No.	Department or Gang	Machine Shop Group No.	Departmental Foreman	Assistant Foreman	Gang Foreman	Leading men (Mechanics)	Total Supervising Forces	Mechanics	Apprentices	Helpers	Laborers	Total
1	Brass Work, Air Brakes, Boiler Pumps	12 & 14	..	..	1	1	2	55	5	1	3	64
2	Valve Motion Gang	8	..	..	1	..	1	19	5	4	2	30
3	Main and Side Rod Gang	7	..	..	1	..	1	25	6	6	2	39
4	Turret Lathe Gang	13	..	..	1	..	1	15	3	2	1	21
5	Manufacturing Tool Room	17	1	.	..	..	1	41	9	7	2	59
6	Machine Shop No. 2	10–4–15–9	..	..	1	3	4	35	13	20	6	74
7	Machine Shop No. 1	5–6–16–3	..	..	1	1	2	37	10	6	4	57
8	Machine Tool Repair Gang	20	..	..	1	..	1	13	0	4	1	18
9	Erecting Shop	..	1	..	8	3	12	157	21	150	28	356
10	Driving Box Gang	2	..	..	1	..	1	32	5	14	2	53
11	Wheel Shop	1	..	..	1	..	1	15	3	10	2	30
12	Superheaters, Steam Pipes, etc.	11	..	..	..	1	1	10	3	6	2	21
13	Electrical Dept. (A).....	..	1	..	2	..	3	50	12	23	6	91
14	Pipe & Tin Shop	..	1	..	4	..	5	83	16	44	4	147
15	Blacksmith Shop (Loco. & Car)	..	1	2	2	2	7	72	14	118	9	213
16	Boiler Shop	..	1	2	7	3	13	176	40	217	37	470
17	Engine Carpenter & Boiler Lagging	..	1	1	..	1	3	23	3	6	13	45
18	Engine Painters	..	..	..	..	1	1	12	5	4	5	26
19	Tender Frame and Truck Gang	..	1	1	..		2	47	8	11	10	76
20	Brass Foundry	..	1	..	..	..	1	18	1	31	2	52
21	Entire Machine Shop (Foreman)	All	1	..	..	..	1	..	..	..	..	..
	TOTAL	..	10	6	32	16	64	935	182	684	141	1942

NOTE—"A" includes Power House Forces and Electrical Crane Operators.



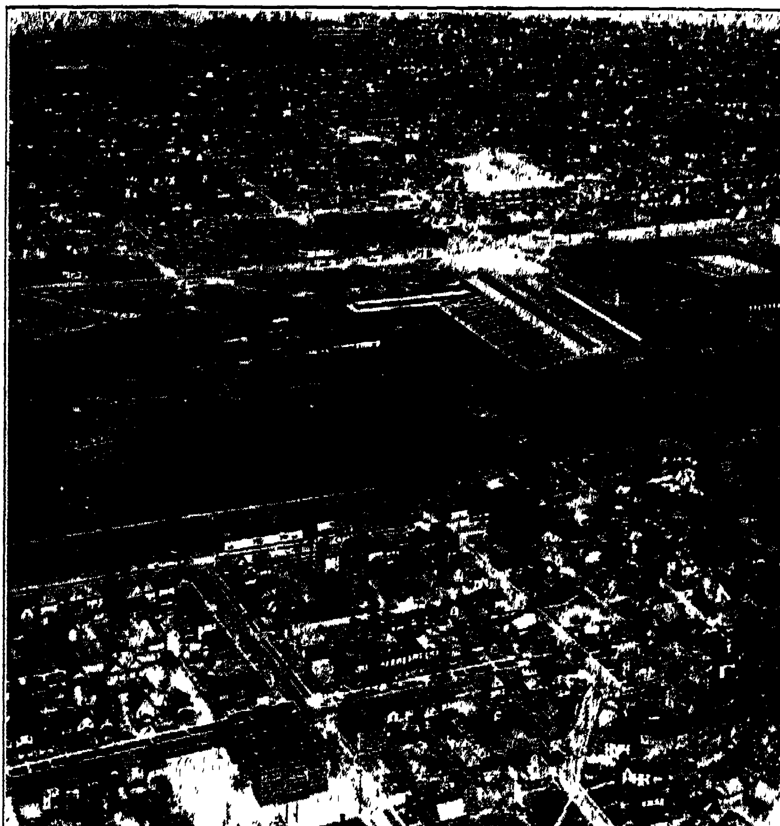
CHESAPEAKE & OHIO RAILWAY CO.
NEW LOCOMOTIVE SHOP
HUNTINGTON, W.VA.

GROUP ANALYSIS

1 - Axle, Crank Pin & Wheel Work.
2 - Locomotive Driving Box & Cellar Work.
3 - Shoes & Wedges.
4 - Frames, Pilot Beams & Draw Castings.
5 - Cylinders & Heads, Steam Chests & Valves.
6 - Pistons & Rods, Crossheads & Guides
7 - Main & Side Rods.
8 - Valve Motion & Reverse Gears.
9 - Spring & Brake Rigging
10 - Engine & Trailer Trucks, Boosters & Stokers
11 - Steam & Exhaust Pipes, Superheaters, etc
12 - Brass Work
13 - Turret Lathe Work.
14 - Air & Boiler Feed Pumps, Pneumatic Devices.
15 - Bolts & Pins.
16 - Throttles, Reverse Lever & Cylinder Cock Rigging, Drifting, Intercepting, & By-Pass Valves.
17 - Miscellaneous Work.
18 - Electric Shop.
19 - Manufacturing Tool Room.
20 - Machine Tool Repair Shop.
21 - Physical Testing Laboratory.
22 - Jacket Work.
23 - Boiler Shop.
24 - Pipe Work.

EXHIBIT "C"

Exhibit E



Airplane Photograph of Huntington (W. Va.) Shops

Appendix C

(3) ADAPTING THE GENERAL LAYOUTS AND DESIGN OF CAR SHOPS FOR INSPECTING AND REPAIRING MULTIPLE UNIT ELECTRIC CARS, COLLABORATING WITH APPROPRIATE COMMITTEES OF DIVISION V—MECHANICAL, A.R.A.

E. A. Dougherty, Chairman, Sub-Committee; W. H. Barton, R. G. Develin, A. T. Hawk, E. E. Kimball, W. A. McGee, B. M. Murdock, H. W. Pinkerton, J. R. Sexton, H. W. Williams, G. I. Wright.

A questionnaire covering this assignment was sent to 9 rapid transit lines and 9 railroads. Answers were received from all the railroads and from 6 of the rapid transit lines.

Analysis of the answers discloses that with one exception where the shops were enlarged, new facilities were constructed to provide for the maintenance and inspection of multiple unit cars.

Multiple unit equipment is usually inspected daily at one end of a run either in a special inspection shed or in the open. Inspection sheds are rectangular, one or more car lengths long, sufficiently wide to accommodate one or two tracks, equipped with track pits and pantagraph walkways. Only light running repairs are performed at the inspection sheds, heavier repairs and periodic overhauling being performed at the shop.

In adapting existing car shops for repairing multiple unit cars additional facilities are required. Space must be provided for motor, transformer, battery and other electrical and mechanical repairs. When the shop is to be used for repairs to ordinary passenger coaches and multiple unit equipment one portion of the building should be assigned to electrical repairs. Track pits the full length of the shop, except for end passageways, should be installed in converting car shops for multiple unit cars. Shop cranes, supplemented by telphers and truck turntables for transverse movement to and from the machine shop should be provided. Capacity of cranes vary from 15 to 30 tons with 25 ton cranes used in many instances. In addition smaller cranes are installed for special purposes. Track centers vary from 16 to 27 ft. with many roads using 16 or 17 ft. Dirt or cinder floors are used in the blacksmith and forge shops. Concrete floors are generally used throughout the shop, although wood block, mastic or wood are used in some instances.

From the information developed in studying this question it appears that passenger car shops lend themselves to those changes necessary to handle the repairs and maintenance of multiple unit cars, as well as the automotive rail cars.

Particular attention is called, however, to the fact that many of the older passenger car shops are constructed of combustible materials and in the event of a fire the equipment in the building would no doubt be seriously damaged resulting not only in a heavy financial loss but also probably in a loss of service to equipment that cannot readily be replaced.

Appendix D

(4) ADAPTING THE DESIGN OF ENGINE HOUSES AND GENERAL LAYOUTS AND DESIGN OF TYPICAL LOCOMOTIVE REPAIR SHOPS FOR THE INSPECTION AND REPAIR OF ELECTRIC LOCOMOTIVES, COLLABORATING WITH APPROPRIATE COMMITTEES OF DIVISION V—MECHANICAL, A.R.A.

E. A. Dougherty, Chairman, Sub-Committee; W. H. Barton, R. G. Develin, A. T. Hawk, E. E. Kimball, W. A. McGee, B. M. Murdock, H. W. Pinkerton, J. R. Sexton, H. W. Williams, G. I. Wright.

A questionnaire covering this assignment was sent to 17 railroads using electric locomotives. Replies were received from 8 railroads.

An analysis of the answers showed that few of the roads had used existing engine facilities for electric power. In general on the eastern roads, where electrified, new facilities were constructed to provide for inspection and repairs to electric engines. One of the western roads in its electrified territory used portions of its engine facilities for handling electric power.

Fig. 1 shows the general features of an existing engine house and shop, in solid lines, adapted to provide for electric power. At this facility there are 23 electric engines handled and in addition in the back shop repairs are made on an assignment of 110 steam locomotives. One stall in the engine house is set aside for the paint shop and 5 stalls are used for electric locomotives, where inspection and light repairs are handled. Heavy repairs requiring dismantling of the locomotive are performed in the shop back of the enginehouse. Space assigned in the shop for electrical work consists of 1000 sq. ft. for armature repairs, an equal area for miscellaneous electrical repairs, and 150 sq. ft. for the instrument or meter room. Pantagraph repairs are made in the enginehouse and occupy approximately 600 sq. ft. Other operations are absorbed by the various facilities throughout the shop. While this shop has been reported as fairly satisfactory it has been suggested that it would be improved by the addition of a crane bay providing for another track and inspection pit as indicated by dashed lines. The extension of the building would also provide space better adapted for electrical work than that used under the present arrangement.

All major repairs on electric power are made at this shop. At the other terminus of the electrified territory the only work performed consists of routine inspection, lubrication and necessary running repairs. At this point a rectangular inspection shed about 36 ft. wide by 120 ft. long was built along one end of the steam engine terminal. This shed provides two inspection pits on parallel tracks with independent track connections at the side of the turntable.

The roads which have had experience with major electrification installations and who answered the questionnaire recommend rectangular inspection sheds in preference to the radial type. Reasons advanced are that the rectangular type affords better light and ventilation and lends itself more readily to the installation of overhead cranes. Several roads recommended the installation of overhead cranes in inspection sheds. With double ended operation of electric locomotives there is no advantage of taking this type of equipment over the turntable and in case of fire there may be a distinct disadvantage due to the delay in moving the equipment from danger. Attention was also called to the desirability of keeping high voltage third rails and overhead wires out of inspection sheds and shops as a safety measure. Equipment is ordinarily handled

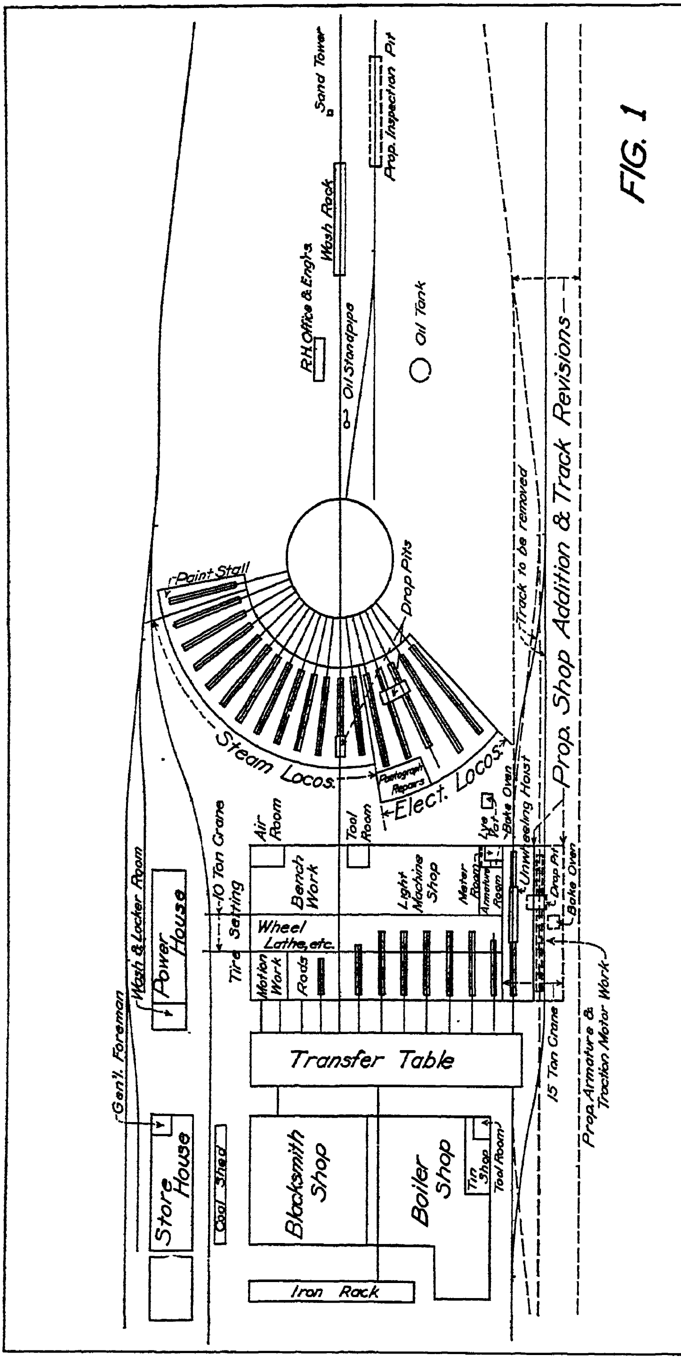

Sand Tower
Prop. Inspection Pit
Wash Rack
R.H. Office & Eng'rs.
Oil Standpipe
Oil Tank
Paint Stall
Drop Pits
Steam Locos.
Pantograph Repairs
Elect. Locos.
Track to be removed
Prop. Shop Addition & Track Revisions
Air Room
Tool Room
Lye Vat
Bake Oven
Unwheeling Hoist
Drop Pit
Bake Oven
Bench Work
Light Machine Shop
Motor Room
Armature Room
10 Ton Crane
Tire Setting
Wheel Lathe, etc.
Motion Work
Rods
Gen'l. Foreman
Wash & Locker Room
Power House
Transfer Table
15 Ton Crane
Prop. Armature & Traction Motor Work
Store House
Coal Shed
Blacksmith Shop
Boiler Shop
Tin Shop
Tool Room
Iron Rack

FIG. 1

over the turntable and in and out of buildings by low voltage detachable cables or self-contained power units. One road calls attention to the fact that the widths of drop pits in existing engine houses are not always satisfactory for electric locomotives. The length of the inspection pits should be as long as the electric locomotive handled. One road used plank floors in the engine house, as well as experimenting with wood block. Other reporting roads use concrete floors.

From the information received in the questionnaire steam locomotive repair shops appear to lend themselves readily to handling electric engines. However, on account of having electrical repairs in addition to the mechanical repairs, more working space is needed adjacent to the shop tracks. Track centers vary in the different installations from 18 ft. to 28 ft. with one road recommending 25 ft. centers. Overhead cranes serve the tracks and working space. Inspection pits are the length of the house except for passageways at the ends. Drop pits should be of the sizes necessary for the different types of electric power handled. Electric locomotives do not require as much shop work as the steam locomotives they displace and room can usually be found for any extra shop tools necessary for electrical work.

Machine tools found in steam locomotive shops will be sufficient for the maintenance of the mechanical features of electric locomotives. Additional tools required for electrical repairs are not many, but of considerable importance. Armature repairs consist principally of hand work and the only equipment necessary outside of special hand tools are commutator soldering machine, coil forming and winding machine, commutator slotting machine, bake oven and an armature banding and commutator turning lathe. These last two operations can be performed on one machine and an ordinary turning lathe can be adapted to this work.

Analysis of the proposition under discussion discloses that essentially it is one of economy, designed to keep down the initial cost of electrification, to avoid so far as possible duplication of operating forces and at the same time provide such facilities as are needed until operating or financial conditions make new facilities necessary or expedient. Initial costs of inspection and shop facilities are not great when compared with the cost of electrification and by building new, they can be planned advantageously to afford economies in operation as an offset to the added expense. Another reason in favor of new facilities is that the location of the existing shop and engine house is not always properly situated to efficiently serve power for electric operations. Ground area required for a given assignment of electrical units is not so great as that required for the steam units they displace; for this reason electrical shops can frequently be located more advantageously. Where the proposed electrification is not great and with few units of electric power to provide for, existing facilities can be altered with small expense to provide for the new type of equipment. It would appear that no set rule can be laid down for this problem and each situation should be studied separately and decided on its merits.

Particular attention is called, however, to the fact that most of the engine houses and many of the older locomotive repair shops are constructed of combustible materials and in the event of a fire the equipment in the building would no doubt be seriously damaged resulting not only in a heavy financial loss but also probably in a loss of service to equipment that cannot readily be replaced.

Appendix E

(6) MODERNIZATION OF ENGINE TERMINALS TO ELIMINATE USE OF STEAM POWER PLANTS FOR OTHER THAN HEATING PURPOSES

A. T. Hawk, Chairman, Sub-Committee; C. M. Angel, H. G. Dalton, A. G. Dorland, Benjamin Elkind, C. E. Harris, L. H. Laffoley, H. C. Lorenz, J. S. McBride, M. J. T. Zeeman.

The necessity for reducing operating expenses has brought out improved devices and methods of handling locomotives at terminals so that at many of the smaller or less important ones it has been found feasible and highly desirable to entirely shut down the power boilers during the warm season of the year, and only operate these boilers at low pressure for heating load during the cold part of the year. This closing down of power plant boilers is obviously more favorable and for longer periods, in the southern and milder climate territory and less favorable in northern and colder climate location, although it will ordinarily be found attractive in some so-called cold climate locations. This does not apply to terminals where "direct steaming" has to be employed to reduce to a minimum the smoke nuisance or at points where extensive engine boiler washing work is done, but can successfully be followed in providing a new, fairly large engine house terminal.

Ordinarily the steam consumed at an engine terminal is used for the following purposes:

1—Steam blowers for firing up locomotives.
2—Heating coaches standing on adjacent coach tracks.
3—Compressing air.
4—Pumping water—(a) From original source to storage tanks.
(b) Washing out engines.
(c) Filling engines.
(d) General purposes—cinder pit, washing floors and pits and toilet purposes.
(e) Fire protection.
5—Engine house and shop heating.
6—Furnishing live steam for waste or other reclamation plants, and for heating water for wash rooms, etc.
7—Generating electric power.

In order to shut down the power plant boilers in summer months, it will be necessary to change the methods of accomplishing the above mentioned work performed by steam.

(1) Steam Blower for Firing up Locomotives

(a) Satisfactory electrically driven fan operated devices are now on the market at a reasonable price. One of these, known as "Loco-Blow" drafting unit, and the other as "Drafto" unit. These are described on pages 964 and 965 of Vol. 31 (1930 Proceedings of A.R.E.A. Convention) and merits of each brought out.

(b) Compressed air may be used in firing up locomotives instead of by a steam blower line. This is usually accomplished by inserting a small pipe down through the engine smoke stack in the smoke chamber, the lower end of the pipe equipped with an inverted cone and arranged to create the required syphon effect to maintain the desired draft.

(2) Heat for Coaches

Heat for coaches is not required during the warm season of the year.

(3) Compressed Air

Where there is a steam driven air compressor, this will have to be replaced with an electric-driven compressor. If compressor is of good design and efficient, it may be possible to change out the steam end and replace with electric motor and belt or other type of drive at a considerable saving over the cost of an entire new compressor; the savings being chiefly in foundation and piping.

(4) Pumping Water

(a) At some locations the steam power plant is used for furnishing steam for pumping all the water for the terminal. In this event, it will be necessary to change out all the steam-driven pumps with, preferably, electrically-operated pump, usually direct-connected, and made fully automatic, thereby requiring a minimum attention.

(b-c-d-e) Boiler washing and refilling pumps. If the pumps are steam driven, they will have to be changed, substituting electrically operated pumps similar to those required for general pumping.

(5) Engine House and Shop Heating

With balance of plant electrically-operated, power plant boilers may be shut down for several months in each year, and only used at low pressure for heating in the cold months. This lowering of pressure of boilers will greatly increase the serviceable use of these boilers and sometimes will relieve the necessity of a licensed engineer to operate. The shut-down period will provide ample time for a thorough overhauling of the boiler including brickwork and insulation.

(6) Furnishing Live Steam for Waste or Other Reclamation Plants

If steam is required for such service for the summer months, a small coal, oil or gas-fired boiler can be installed in the immediate vicinity of the plant that can be fired by the reclamation plant attendant, when required. This type of boiler may be an old Baker heater now commonly used in passenger gas-electric equipment for heating.

(7) Generating Electric Power

Where electric power is generated at a terminal, it is generally understood that it must be a terminal of some considerable importance that would not normally be considered for modernization. However, there are, presumably, some small terminals having electric turbine generators for light load only, these having been provided before the locality had an adequate, dependable outside-owned electric plant or available power line. In such cases the old, light-load generators are out of date, and not efficient, so that it may be found economical to replace these with purchased power for both the power and light load.

TO ESTIMATE THE APPROXIMATE SAVINGS

(1) Determine the cost during the previous non-heating period in wages of firemen and common labor in operating boiler, including the unloading and handling of coal, the loading up of ashes, the coal used in making steam, supplies used, and the maintenance labor and materials used during the previous similar period.

(2) Determine just how many days or months no steam will be required for heating.

(3) The amount of all the water to be pumped and repumped for the different requirements.

(4) The number of engines that are fired.

(5) The amount of compressed air required.

Determine the cost of doing this work by applying the proper rate of electric power required, including the interest charges on the additional investment and consideration of any difference in depreciation and maintenance over the original equipment replaced.

Three tests were made by the Rock Island in 1928 to develop the relative economy of firing locomotives by "Locoblow" device as against the common practice of firing by steam blower, this being made on the same locomotive as representative Mikado freight service engine. A synopsis of results of this test is quoted below.

Cost of steam was based on assumption of boiler efficiency of 65 per cent and that it would require one pound of coal to evaporate 6.5 lb. of water.

Cost of coal used was \$2.88 per ton or \$0.00144 per pound
The cost of fuel to produce 1000 lb. of steam \$0.221
The cost of water at 7.5¢ per 1000 gallons figured
0.0114¢ per 1000 lb. steam.

Fuel	\$0.221
Water	0.014
	\$0.234 = Cost per 1000 lb.

steam for these two items only, without the cost of labor, maintenance and interest charges.

The cost of electric energy for the fan system test was \$0.0215 per k.w.h.

The average length of time to fire up locomotive, starting with 164° Fahr. temperature fill-up water raised to 60 lb. steam pressure was 55.2 minutes for the steam blower and 48.5 minutes for the Locoblow, average time of fire lighting torch required for steam blower was 27 minutes against 18 for the Locoblow.

The Burlington reports the cost of firing up by fan system at about 6¢ per hour; while the cost of firing up by air is about 20¢ per hour. This is exclusive, however, of any overhead charges on the investment, motor-operated blower over the air piping cost. As information, the air required is about 94 cu. ft. of air per minute to operate their air blower at 100 lb. air pressure at the nozzle.

The Erie reports that they are producing compressed air at one of their modern plants at 3¢ per 1000 cu. ft., which would make the cost of firing up with air at about 17¢ per hour.

Considerable oil burning equipment is operated in southern or warm climates, and steam is commonly used to atomize the fuel oil in firing locomotives. Where natural gas can be obtained at a reasonable rate, it may be found economical to use gas to fire up the locomotive to generate enough steam to atomize the fuel oil. In this event it is usually found economical to close down the power plant during the warm season and only operate the boilers for heating during the cold season.

It may be found economical in some locations to use compressed air instead of using an electrically operated blower in order to reduce the interest charges.

Appendix F

(8) DESIGN OF INSPECTION PIT

H. C. Lorenz, Chairman, Sub-Committee; C. M. Angel, F. C. Baluss, Benjamin Elkind, A. S. Kent, L. H. Laffoley, W. S. McFetridge, E. S. Pennebaker, S. E. Shoup, M. J. T. Zeeman.

Locomotive inspection pits are for the purpose of inspecting locomotives, as follows:

(1) Before entering enginehouse, to save dispatchment time. (In a terminal turning 40 locomotives per day, it has been estimated that a saving of seven and one-half minutes per locomotive may be effected.)

(2) In cases of engines running through a terminal or switch engines working on a 24-hour shift. (All the enginehouse work is done while engine stands on inspection pit.)

(3) Where enginehouse facilities are not modern or are too small for the power.

(Other conditions may obtain to warrant installation, but on account of varied requirements and practices on different railroads, the use of inspection pits is not general.)

Inspection pits are usually located either between turntable and washing platform, or just beyond coaling or fuel station, i.e., on the side farthest from turntable.

Recommendations

Inspection pits should be three to four feet deep, measured from base of rail, of a length not less than the longest locomotive to be inspected, and provided with ample drainage.

Convenient access should be provided by stairway. (In some instances, direct access has been provided from inspector's office by tunnel.)

Fixtures should be provided for general lighting and service outlets for extension cord, for detail inspection.

A telephone should be provided for communication with enginehouse, and may be supplemented by the installation of a pneumatic tube system for sending reports to the enginehouse.

Appendix G

(9) ENGINE TERMINAL LAYOUTS

J. M. Metcalf, Chairman, Sub-Committee; W. H. Barton, H. G. Dalton, R. G. Develin, T. H. Gardner, J. S. McBride, H. W. Pinkerton, E. H. Roth, John Schofield, S. E. Shoup, H. L. Smith, H. W. Williams, D. E. Woozley.

(a) STEAM LOCOMOTIVES

This Committee has made two previous reports on the subject of Engine Terminal Layouts for steam locomotives, which appear in the Proceedings, Vol. 23, 1922, pages 351 to 359, and Vol. 27, 1926, pages 276 to 293.

In these reports the general principles governing design of engine terminals were considered at some length, and the requirements for the various facilities and their relation to each other were discussed in detail. In 1922 a plan of an ideal layout was submitted for discussion and as information only. In 1926 the conclusions now appearing in the Manual were adopted as recommended practice. These cover general

principles of design only, and do not undertake to furnish guidance for specific problems. The Proceedings and Manual contain also, under various headings pertaining to individual facilities, discussions and recommendations bearing on layout design.

The Committee did not, when the previous reports were submitted, and does not now believe that it is practicable or desirable to adopt as recommended practice even a general plan for engine terminal layout. Too many factors, varying with each individual case, control the details of design. The size and shape of the ground area available and its relation to the train yard in many cases fix the fundamental features of the layout. The requirements as to number of road and yard engines to be received and dispatched per day and at peak hours, number and class of repairs to be made, kind of fuel and its source as affecting necessary storage, and many other questions are of value to the man faced with the problem of designing for other circumstances as an illustration only. It is not, in the opinion of the Committee, desirable that any such layout be set up in the Association's Manual of recommended practice. It is thought, however, that a more extended statement of general principles might very well appear in the Manual for the guidance of those working on layout problems. Such an elaboration of the conclusions now in the Manual is submitted at the end of this report, with the recommendation that it be substituted for the matter previously adopted.

There have been no marked developments in steam engine terminal layout design since the fairly full report of 1926. The lengthening of locomotive runs with continuous operation of the same locomotive by two or more crews over two or more divisions has been among the outstanding changes in locomotive operation in recent years. This results in reduction in the number of locomotives tying up at the intermediate terminals. It means that such terminals must be designed to facilitate quick cleaning and inspection of the through locomotives and their prompt return to their trains without being turned or entering the enginehouse. Additional flexibility in track layouts to accommodate such return movements becomes desirable. In some cases, such intermediate terminals may include only facilities for cleaning, inspection and serving with fuel and water. Under such conditions a wye may prove more economical for such turning of locomotives as will be required than a turntable and the layout may include no enginehouse or shop facilities, or a rectangular enginehouse only.

Conclusions

General

1. In designing an engine terminal layout, a thorough study of the traffic and operating requirements of the terminal should be made jointly by the Engineering, Operating and Mechanical departments. This study should include consideration of the following data:

(a) Type and size of locomotives to be handled.
(b) Number of locomotives handled in each direction daily by classes.
(c) Schedule of arrival and departure of locomotives by classes.
(d) Number of locomotives arriving during peak period.
(e) Time within which locomotives arriving must be hostled by classes.
(f) Maximum number of locomotives in terminal at one time.
(g) Number of locomotives repaired daily by classes of work.
(h) Number of locomotives under repair at one time by classes of work.
(i) Amount of fuel (coal or oil) issued daily.
(j) Amount of water consumed daily.
(k) Amount of sand consumed daily.
(l) Number of men required to operate the terminal.

2. A terminal should be designed not only to meet present requirements but also with provision for future expansion.

3. In order that the time locomotives are held at a terminal may be reduced to a minimum the engine terminal itself must be coordinated with all other facilities so that the movement of each locomotive may be orderly and expeditiously made from the time it is detached from its train in the yard or at the station until it is again attached to a train with its fires cleaned, coal, water and sand taken, oiled, and with any needed repairs made.

4. The required facilities should be provided and arranged in the sequence in which it is desired that incoming and outgoing locomotives be served by them.

Site

5. The selection of an economic site requires a study of all factors affecting cost of construction and of operation, including:

(a) Land value.
(b) Cost of preparing site and of foundations.
(c) Drainage, sewer disposal, water supply, electricity.
(d) Relation to existing or proposed yards and to passenger and freight stations.
(e) Labor supply, including housing facilities and transportation.
(f) Fire protection.

Track Layout

6. Unless there is a sufficient number of locomotives handled to warrant duplicate coaling and ash facilities, the layout should be designed for all locomotives to enter the terminal proper from the same end, but where possible a separate exit should be provided for additional flexibility in movement and so that in case of derailment or other trouble at the main entrance the terminal will not be tied up.

7. Sufficient and properly laid out trackage should be provided to permit the prompt receipt of all locomotives immediately upon arrival, and in advance of each facility for standing locomotives which may have to wait their turn. Where climatic conditions permit outside storage, sufficient trackage should be provided for locomotives ready for service, in order to reduce the size of the engine house to a minimum, and so it will not be necessary to overload the turntable during the peak outbound period.

8. The layout should provide for the orderly movement of locomotives without reverse movement between the entrance and the turntable, without regard to the time of arrival of preferred locomotives.

9. Crossovers should be so arranged that yard locomotives, or others that do not require turning, may have their fires cleaned, and take coal and water without crossing the table.

10. All approach and departure tracks to and from the turntable should line across the table with engine house tracks to permit convenient movement of dead locomotives or carloads of supplies into or out of the engine house. Stub end tracks on side of turntable opposite engine house and in line with pit tracks, are also desirable. Stall angle of enginehouse should be such that when extended beyond a half-circle the pit tracks will line up across the turntable.

11. Sufficient tangent should be provided on all turntable approach tracks to permit straightening of engine trucks before passing onto turntable.

Water Facilities

12. Sufficient water columns should be located near the terminal entrance to serve all locomotives entering the terminal. These should be at sufficient distance from the entrance to permit all locomotives which arrive in a short period of time (15 to 30 minutes) to clear the main line.

13. Water columns should also be located as near as practicable to the turntable so that locomotives housed or stored for long periods may take water without moving the entire length of the terminal. In some cases provision for filling tanks while locomotives are standing in the house may be desirable.

Office and Service Buildings

14. Adequate office facilities should be provided for the officer in charge of the terminal, and at a terminal handling 75 or more locomotives per day a separate building should be provided, in which the crew dispatchers should also be located. This building should be adjacent to the engine house and so located that the officer in charge may see the entire terminal from his office window, as should also the crew dispatchers.

15. The oil and lantern buildings should be of fireproof construction located near the turntable where engine supplies can be conveniently obtained, and should be separate from the general store building, in order to provide more convenient access for engine crews and to decrease fire hazard.

16. Depending upon the relative amount of light repair work and determined from an actual performance record, a light running repair shed near the engine house may be justified to permit the handling of light repairs outside the engine house. This building should be located with double end tracks, with pits its entire length. The building should be well lighted with natural and artificial light, and provided with steam, air and water.

Lighting

17. The entire terminal should be artificially lighted, with lights so located as to particularly facilitate the cleaning of fires, taking fuel, water and sand, and the turning of locomotives, without throwing a glaring light into the eyes of the engine runners.

Telephones

18. Every office and building should be connected by telephone with the engine dispatcher, who should also have telephone connection with the yard office, towers and train dispatchers.

Fire Protection

19. Fire hydrants with hose houses and equipment should be located at various points on the terminal, so as to provide at least two streams of water on any structure.

20. Mains and hydrants should be located with due regard to future expansion of the terminal.

21. It is recommended that pipe lines be built in loops so as to give even pressure at all points.

22. The terminal should be equipped with chemical extinguishers conveniently placed as protection especially against oil and electric fires.

23. Fire roads, conveniently located to provide access to fire fighting facilities and to all buildings, should be provided.

Other Facilities

24. For recommendations as to other facilities which should be included in engine terminal layouts, see matter under separate heads in the Manual and Proceedings as follows:

Cinder Pits—Supplement to Manual, Bull. 327, pages 90–92.
Coaling Stations—1929 Manual, pages 1491–1499.
Fuel Oil Stations—1929 Manual, pages 1489–1491.
Sand Facilities—1929 Manual, pages 1499–1511.
Inspection Pits—Proceedings Vol. 32, pages 499–500.
Washing Platforms—Proceedings Vol. 32, pages 485–486.
Turntables—1929 Manual, page 1471.
Engine houses—1929 Manual, pages 1471–1476.
Storehouses—1929 Manual, pages 1482–1488.

(b) ELECTRIC LOCOMOTIVES

Engine terminal layouts for electric locomotives involve fewer kinds of service and are correspondingly simpler in track layout and arrangement than those for steam locomotives. It is customary for electric locomotives to be designed for double-end operation. This feature lends itself to rectangular engine house and terminal layout without turntable.

The number of such terminals is still comparatively few and the conditions which they serve and the practice of different roads in their designs are so varied that the committee did not feel justified at this time in presenting recommendations on this subject for the Manual. Three illustrations showing representative layouts are submitted herewith as information.

Fig. 1 is an ideal layout suggested by a western road. A wye is provided for such turning operations as may be necessary. It is assumed that power would be received and dispatched from the left end of the layout, the lower track being the incoming track. The locomotive would pass over the washing platform into the inspection shed, where it would receive terminal inspection and repairs and adjustments when only nominal work was required. At the same time, the locomotive would be serviced, lubricated and supplied with sand and with oil and water for train heating. If no other repairs were necessary, it would be passed over the crossovers to the outgoing track, or run around the wye if turning was desired.

Fig. 2 and 3 show terminal arrangements at the ends of electrified terminal districts, where electric operation is replaced by steam locomotives. Both include similar direct movement, with rectangular inspection shed, used only for running inspection and light repairs.

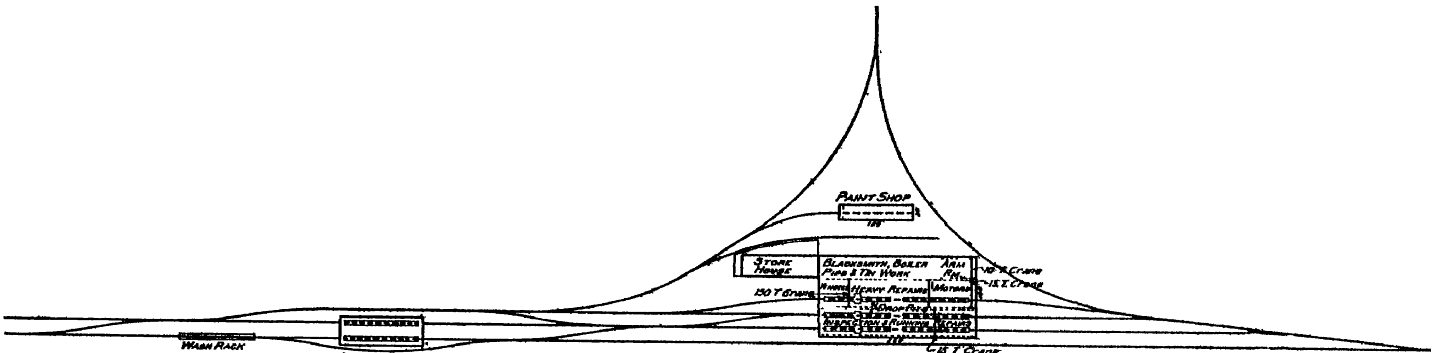


FIGURE 1.

PROPOSED SHOP & TERMINAL FOR ELECTRIC LOCOMOTIVES

SCALE-FEET

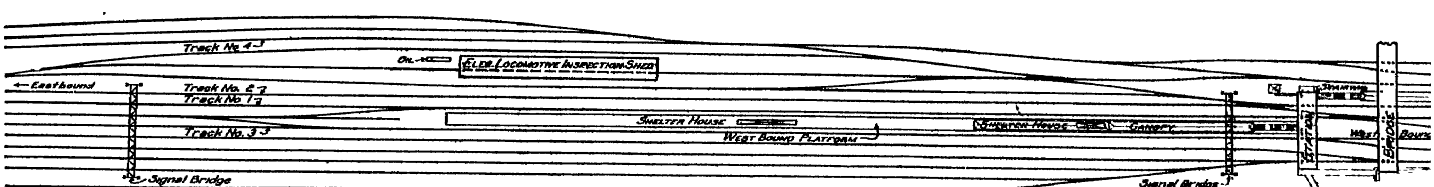


FIGURE 2.

ELECTRIC LOCOMOTIVE TERMINAL LAYOUT

NEW YORK CENTRAL R.R.
HARMON, N.Y.

SCALE-FEET

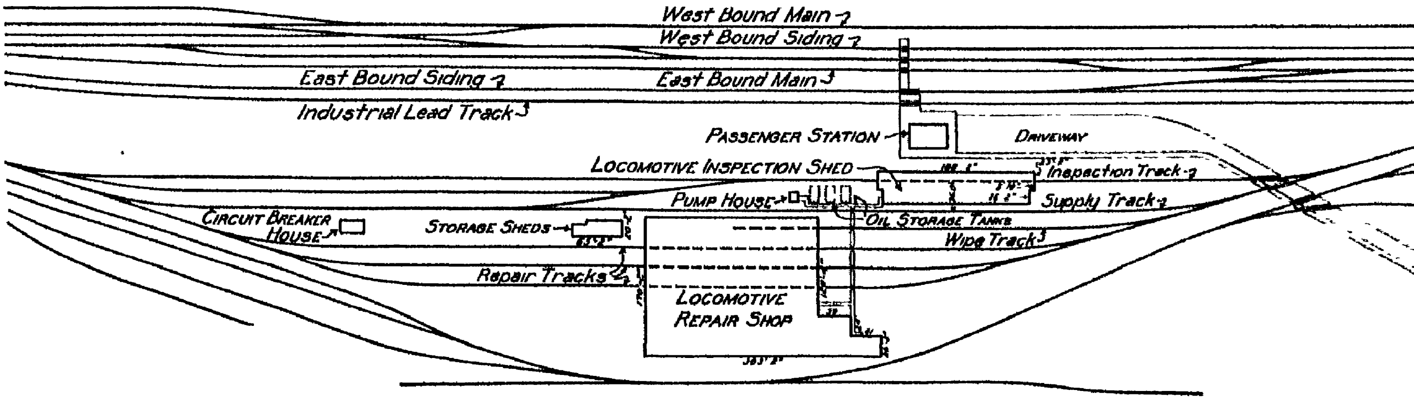


Figure 3.

Electric Locomotive Terminal Layout

Cleveland Union Terminal Co.
Collinwood Yard

Scale—Feet

REPORT OF COMMITTEE III—TIES

W. J. BURTON, *Chairman;*
S. V. ARDAGH,
R. S. BELCHER,
M. S. BLAIKLOCK,
W. C. BOLIN,
H. F. BROWN,
J. F. BURNS,
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E. L. CRUGAR,
H. R. DUNCAN,
C. W. GREENE,
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C. S. KIRKPATRICK,
F. C. KRELL,
M. F. LONGWILL,
A. F. MAISCHAIDER,
JOHN FOLEY, *Vice-Chairman;*
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L. G. PASTOR,
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L. J. RIEGLER,
J. H. ROACH,
S. S. ROBERTS,
S. RODIGUEZ,
S. E. SHOUP,
L. L. TALLYN,
E. H. THORNBERRY,
J. A. VARDON,
HARRY WEIGHTMAN,
J. W. WILLIAMS,
K. G. WILLIAMS,
W. W. WYSOR,
R. C. YOUNG,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following assigned subjects:

(1) Revision of Manual.

(2) Extent of adherence to Standard Specifications (Appendix A).

(3) Substitutes for wooden ties (Appendix B).

(4) Tie renewal averages and costs per maintained mile, securing data from reports to Interstate Commerce Commission (Appendix C).

(7) Economics of use of 8½-foot and 9-foot ties as compared with 8-foot ties.

(9) Methods of dating cross-ties (Appendix D).

The Committee wishes to report progress on Subjects 5, 6 and 8, but is not yet able to present any results.

Action Recommended

(1) No revision of the 1929 Manual, as supplemented by Bulletins 327 and 337, is proposed.

(2) That the reports contained in Appendices A, B, C and D be received as information.

(3) That subjects (2), (3), (4), (5), (6), (7) and (8) be continued.

Respectfully submitted,

THE COMMITTEE ON TIES,
W. J. BURTON, *Chairman.*

Bulletin 343, January, 1932.

Appendix A

(2) EXTENT OF ADHERENCE TO STANDARD TIE SPECIFICATIONS

John Foley, Chairman, Sub-Committee; J. F. Burns, R. L. Cook, C. W. Greene, J. E. King, M. F. Longwill, M. J. McDonough, H. C. Munson, J. H. Reeder, L. L. Tallyn, E. H. Thornberry, J. W. Williams, K. G. Williams.

Conditions in the tie trade continued through 1931 as they were in 1930, with both consumers and distributors holding more ties than they could use or dispose of. Thus for another year there were no competitive conditions to provide an excuse for the production or purchase of sub-standard ties.

No examinations of ties were made by the Committee as a whole. Observations of stocks of ties by individual members of the Committee resulted in the general impression that the reduced number purchased and added to railroad stocks maintained the close proximity to standard which was reached during 1929 and 1930. The widest departures from standard ties are to be found in the stocks containing ties purchased under inspection which provides for the acceptance of sub-standard ties as so-called "usable culls" or "serviceable rejects".

Improvements in the surroundings which affect satisfactory seasoning resulted from insistence on standard practice in sanitation and stacking where ties had previously been handled without regard for A.R.E.A. recommendations for seasoning.

Progress in the adoption of the standard specification for ties was marked by its substitution for the United States Railroad Administration specification on the part of a railroad with over 14,000 miles of maintained track.

Division VI—Purchases and Stores, of the American Railway Association, referred a recommendation of its Committee on Subject 5—Forest Products, that the grouping of the kinds of wood in the standard specifications for ties be reviewed and consideration given to regrouping them according to their market value.

Each group of woods in the standard specifications for ties represents the kinds of woods which are within a reasonable range of strength as ties and which take preservative treatment together in the same cylinder charge without widely varying results. The grouping also keeps together ties of the kinds of wood which can be used together. This standard grouping starts the separation of the ties as early in their handling as possible; at the point of production or shipment.

The market values of whatever kinds of wood a railroad may wish to order will vary as between woods, as between years and as between localities. Any grouping of woods based on market values would neither be stable nor acceptable for countrywide use. Some woods are worth more where they grow in such quantity that they can be utilized in meeting demands for specific products other than ties. The same woods, elsewhere than in the locality of the specific demand, may have much lower market values.

Where the pricing of ties by groups is not practical, a price for each kind of wood or for such combinations of woods as the purchaser desires is the privilege of each railroad under the standard specifications for ties. A permanent grouping on the basis of price is impracticable. The market value of birch where it is in demand for furniture stock may be equalled by that of hickory where the latter is being exploited for handle stock; yet the value of either may be far lower than that of the other where one is less marketable than the other.

The kinds of wood which a railroad desires to use and the proportions of such kinds it desires to purchase may make grouping of any kind unnecessary so far as use is concerned. Consequently, when the standard specifications for ties were under con-

sideration, the woods listed as acceptable were sorted into groups which represented selections for approximately equal serviceability. The Committee is convinced that any grouping of woods on the basis of their market values as ties would be subject to frequent changes and it believes that the grouping which is standard should prevail as more practical than one predicated on prices.

Appendix B

(3) SUBSTITUTE TIES

S. B. Clement, Chairman, Sub-Committee; S. V. Ardagh, L. J. Riegler, E. H. Thornberry, J. A. Vardon, H. Weightman, W. W. Wysor.

REPORTS FROM RAILWAYS MAKING TESTS OF SUBSTITUTE TIES

Atlanta & West Point Railroad

Reported by S. R. Young, Assistant Chief Engineer.
Date—June 5th, 1931.
Kind—Duke Reinforced Cross Tie.

The ties originally installed are all reported as still in the track. No new installations have been made.

Bangor & Aroostook Railroad

Reported by P. C. Newbegin, Chief Engineer.
Date—June 2nd, 1931.
Kind—Maine Concrete.

An inspection of these ties, made April 27th, 1931, showed them to be in first-class condition, and with no evidence of failure except in the case of three ties. In one case the concrete on top of the tie had broken away from the reinforcement for about six inches on the inside of the concrete block, but not to affect the services of the tie. In another case the concrete had broken off from the top of the block above the reinforcement from the inside end of the concrete back to under the rail, so that there was practically no bearing for the rail base. This tie was removed about May 15th, 1931. In the third case the concrete under the rail had begun to break up somewhat, and if this continues, it will have to be removed within a short time.

Bessemer & Lake Erie Railroad

Reported by F. R. Layng, Chief Engineer.
Date—July 9th, 1931.
Kind—Brown Concrete.

The Brown ties at present are showing some sign of disintegration and in a few instances some serious cracks have developed under the rail. No ties as yet have been removed.

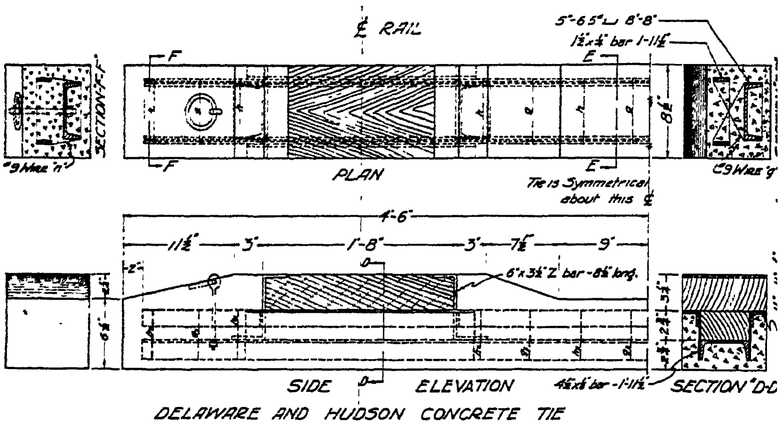
Delaware & Hudson Company

Reported by H. S. Clarke, Engineer Maintenance of Way,
Date—June 5th, 1931.
Kind—Dalton.

Tests were so satisfactory that tie plant was installed for fabricating these ties, and number installed to date is 35,000.

Reported by M. J. McDonough, Division Engineer,
Date—June 24th, 1931.
Kind—Concrete Tie.

Forty-three of these concrete ties were placed in northbound main track, North Albany Yard, in July, 1926. There has been no trouble or failures experienced in connection with these ties in any respect, although the wood blocks to which the rails are spiked are about ready for renewal at this time. These blocks are crushing due principally to checking and splitting of the timber.



DELAWARE AND HUDSON CONCRETE TIE

Fig. 1.

Note.—This tie has not previously been reported. It is a concrete tie with structural steel reinforcing with oak and yellow pine spiking blocks, as shown in Fig. 1.

Duluth & Iron Range Railroad

Reported by E. H. Dresser, Vice-President and Chief Engineer.
Date—June 12th, 1931.
Kind—Carnegie and Hatch.

Forty-eight Carnegie ties were removed during the year. No Hatch ties were removed.

Duluth, Missabe & Northern Railway

Reported by E. H. Dresser, Vice-President and Chief Engineer.
Date—June 12th, 1931.
Kind—Carnegie and Kimball.

Three hundred and two Carnegie ties were removed during the year. The thirty Kimball ties originally installed are all in track.

Elgin, Joliet & Eastern Railway

Reported by A. Montzheimer, Chief Engineer.
Date—Aug. 19th, 1931.
Kind—Bates and Carnegie.

Referring to the 62 Bates Concrete Ties installed in the year 1912, wish to advise that 56 remained in service on August 15, 1931. Two were removed during the month of June, 1930, on account of tie rods, or reinforcing rods being rusted through at the end of the concrete in center of track, as reported in my letter dated October 22, 1930. Four ties were removed during the month of August, 1931, for the same reason as those taken out of service during June, 1930. At present, six of the remaining ties have the two upper reinforcing rods rusted through but the two bottom rods in the center of the track, are still in fair condition and ties will remain in service.

Detailed statement showing Carnegie Steel Switch and Steel Cross-Ties in track on July 1, 1930, has been received and is available for final report.

Los Angeles Railway

Reported by B. J. Eaton, Engineer Way and Structures.
Date—June 3rd, 1931.
Kind—McDonald Concrete.

There is a reduction in number of ties in track in comparison with previous reports.

SUMMARY OF TESTS OF SUBSTITUTE TIES, NOW IN PROGRESS, 1931

Railroad	Name of Tie	Location	Date Put in	Number Put in	Number Now in	Ballast	Rail Section, Pounds	Traffic
Atlanta & West Point	Duke	Louise, Ga.	1927	10	10	Stone and gravel	90	A
Bangor & Aroostook	Maine	Hudson, Me.	1923–4	69	68	Gravel	85	A
Bessemer & Lake Erie	Brown	Oakmont, Pa.	1930	1,500	1,500	Slag	130	C
Delaware & Hudson	Dalton Steel Tie	Various	1927–31	35,000	35,000	Cinder	90	E
	Concrete Tie	N. Albany Yard	1926	43	43			
Duluth & Iron Range	Carnegie	Various	1908–9	2,000	889	Gravel	80	C
	Hatch	Two Harbors, Minn.	1928	11	7	Gravel	80	C
Duluth, Missabe & Northern	Carnegie	Various	1908–9	22,380	19,095	Crushed Rock	100	A
	Kimball	Virginia, Minn.	1914	30	30	Gravel	100	C
Elgin, Joliet & Eastern	Bates	Whiting, Ind.	1912	62	56	Crushed Rock	85	C
	Carnegie	Various	1909–18	15,514	3,997	Gravel, Cinders, Slag	85–100	C
	Carnegie Switch	Various	1912–27	525,842	42,682	Gravel, Cinders, Slag	85–100	C
Los Angeles Railway	McDonald Concrete	Los Angeles, Cal.	1911	4,323	627	Solid Concrete	87	B
Pennsylvania Railroad	Riegler Concrete	Emsworth, Pa.	1908	15	6	Stone	130	A
	Snyder Composite	Pittsburgh Div. Yards	1907	2,255	1,157	Cinder	100	F
		Aspinwall, Pa.	1925	100	98	Cinder	130	C
		Hayes, Pa.	1925	410	400	Stone	130	C
		Monongahela, Pa.	1927	2,516	2,503	Cinder	130	A
		Wilkinsburg, Pa.	1928	1,861	1,860	Stone	130	E
		Pitcairn, Pa.	1928	3,336	3,336	Cinder	130	C
		Derry, Pa.	1927	1,978	1,944	Cinder	130	E
	Brown Concrete	Conpitt Jct., Pa.	1927	2,843	2,843	Stone	130	C
		Tunnelton, Pa.	1928	2,385	2,385	Cinder	130	A
		Bellwood, Pa.	1927	3,006	2,508	Stone	130	C
		Highspire, Pa.	1927	1,486	1,398	Cinder	130	C
		M. P. 31—A. & S. Branch	1927	517	439	Cinder	130	C
		Haines, Pa. C. & P. D.	1927	970	912	Stone	130	A
		Conowingo, C. & P. D.	1927	1,986	1,930	Stone	130	A
		Octoraro, Pa. C. & P. D.	1927	1,993	1,731	Stone	130	A
	Silver Steel & Concrete	West Morrisville, Pa.	1922	102	4	Cinder	130	C
	Willis Concrete	Manhattan Produce Yard	1927	24	24	Cinder	100	F
Southern Pacific Lines	U. S. Indestructible	Eagle Pass, Texas	1916	23	22	Cinder	80	D
St. Louis & San Francisco	Clark-Applegate	Springfield, Mo.	1914	125	125	Cinders and gravel	85	C
Terminal R. R. Assn. of St. Louis	Miller	St. Louis, Mo.	1924	100	100	Cinder	100	A

* Linear feet

A—High speed, heavy service, passenger and freight.
B—High speed, exclusively passenger.
B.1—Slow speed, exclusively passenger.
C—Heavy service, exclusively freight.
D—Main Track, light service.
E—Yard track with heavy switching.
F—Yard track with light switching or storage usage.

Pennsylvania Railroad—Eastern and Central Regions

Reported by T. J. Skillman, Chief Engineer.
Date—September 21st, 1931.
Kind—Riegler, Snyder, Brown, Silver and Willis.

RIEGLER—Eight ties crushed and broken under rail were removed in July, 1931. Six of the original fifteen ties placed in track in 1908 are still in service.

SNYDER COMPOSITE—Four ties to be removed soon on account of clips badly rusted. Clips missing on 40 ties. 174 ties in bakeoven at Pitcairn Steel Car Repair Shop under high heat constantly, in fair condition.

BROWN CONCRETE (Casey):

Aspinwall, Pa.—Twenty-two ties crumbling, fifty-six cracked, twenty fair condition.

Hayes, Pa.—Twelve ties broken at middle, four broken under rail, four have lugs sheared off at end of tie.

Monongahela, Pa.—Sixty-six ties disintegrating. Will probably be removed this year.

Wilkinsburg, Pa.—Condition good except the wooden blocks under tie plates are splitting.

Pitcairn, Pa.—Some ties are broken due to heavy objects dropping. As ties are not adapted for regaging, it will be necessary to renew rail on curve. The receiving ends of rail show considerable cupping due to wear of wooden blocks under tie plates; many of the blocks are split.

Derry, Pa.—Condition good, except seven ties have developed defects. Rail has been changed.

Conpitt Junction, Pa.—One hundred and eleven ties have developed defects which expose reinforcement.

Tunnelton, Pa.—Two ties broken under rail. Ends crumbling on five ties. Others generally in good condition.

Bellwood, Pa.—498 ties removed due to failure of concrete; 104 in track cracked through between rails. 84 ties in track crushed under rails. Seven in track cracked through outside of rails. 269 ties in track ends broken off at reinforcing steel.

Highspire, Pa.—88 ties removed due to failure of concrete; 79 in track cracked through between rails. 14 ties in track crushed under rail; 1 in track cracked through outside of rails.

M.P. 31, A.&S. Branch—Seventy-eight removed due to failure of concrete; seven in track cracked through between rails. Six ties in track crushed under rail; 1 in track cracked through outside of rail.

Haines, C.&P.D.—Fifty-eight removed due to failure of concrete; 14 in track cracked through between rails. Twelve ties in track crushed under rail; 18 in track end broken off at reinforcing steel.

Conowingo, C.&P.D.—Fifty-six removed due to failure of concrete—50 in track cracked through between rails. Fourteen ties in track crushed under rails; two in track cracked through outside of rails. Thirty-three tie ends broken off at reinforcing steel.

Octoraro, C.&P.D.—Sixty-two removed due to failure of concrete; 19 in track cracked through between rails. Fifty-seven tie ends broken off at reinforcing steel; 10 in track cracked through outside of rails.

SILVER-STEEL AND CONCRETE, West Morrisville, Pa.—Ninety-eight ties removed during 1928 due to breaking of castings and crushing of concrete.

WILLIS CONCRETE, Manhattan Produce Yard—All ties removed due to failure May 13th, 1931.

Southern Pacific Lines

Reported by E. A. Craft, Engineer Maintenance of Way.
Date—June 12th, 1931.
Kind—U. S. Indestructible.

There are 22 of these test ties still in track and in good condition. The original wooden spiking blocks, however, have been removed on account of decay and were replaced by blocks made from creosoted ties.

St. Louis–San Francisco Railway

Reported by F. G. Jonah, Chief Engineer.
Date—June 1st, 1931.
Kind—Clark-Applegate.

The ties are getting badly corroded on the outside, and some of the lugs holding the wood fillers in place are badly oxidized and no longer giving service.

Terminal Railroad Association of St. Louis

Reported by H. J. Pfeifer, Chief Engineer.
Date—August 25th, 1931.
Kind—Miller.

The ties are still in the track and in first-class condition, none of them having been removed and no expense of any kind having been incurred in connection with them since they were installed. Judging their present condition, there is every reason to expect a life for these ties of 30 years or more.

Appendix C

(4) TIE RENEWAL AVERAGES PER MILE MAINTAINED

S. S. Roberts, Chairman, Sub-Committee; M. S. Blaiklock, J. F. Burns, M. J. McDonough, J. H. Roach, S. E. Shoup, L. L. Tallyn.

Tables A and B herewith, give the 1929 tie renewals as reported to the Interstate Commerce Commission, or in the case of the two principal Canadian railways, as reported to the Committee in the same form.

The tables continue the traffic density figures compiled for the first time last year. The renewal data is presented for the fourth year. After the receipt of 1931 figures, the Committee proposes to include a tabulation of five-year averages.

TABLE A

CROSS-TIES LAID IN REPLACEMENT - CLASS 1 STEAM ROADS IN UNITED STATES

Calendar Year Ended December 31, 1930

Road	Wooden ties untreated (U) Number	Wooden ties untreated (U) Average Cost	Wooden ties Treated (T) Number	Wooden ties Treated (T) Average Cost	Ties other than wood (S) and second-hand ties re-applied	Total Ties Applied	Miles of maintained tracks (Item 24)	Estimated total cross-ties in all maintained tracks (Item 23)	Equated gross ton-miles d
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND REGION:									
Bangor & Aroostook	214,818	$ .82	-	-	-	214,818	846.46	2,436,479	1,723,202,408
Boston & Maine	176,665	1.11	764,913	$1.76	-	941,578	3,987.04	10,775,000	17,104,170,408
Canadian National Lines in N.E.	11,782	.97	29,349	1.81	-	41,131	257.51	824,032	606,393,856
Canadian Pacific Lines in Maine	6,846	.60	61,638	1.31	-	68,484	213.71	617,529	1,162,385,128
Canadian Pacific Lines in Vermont	-	-	38,519	1.32	-	38,519	123.25	385,516	665,181,440
Central Vermont	328	1.09	136,753	1.75	-	137,081	562.85	1,803,000	2,643,804,952
Maine Central	306,739	1.06	27,713	1.73	-	334,452	1,371.49	4,160,000	4,350,044,072
New York Connecting	-	-	5,050	1.97	-	5,050	25.98	82,861	367,002,960
New York, New Haven & Hartford	1,802	1.17	1,148,557	1.63	-	1,150,359	4,553.08	14,093,214	24,346,345,064
Rutland	-	-	117,930	1.63	-	117,930	526.14	1,578,949	1,939,372,560
GREAT LAKES REGION:									
Ann Arbor	-	-	62,095	1.53	-	62,095	419.12	1,257,360	1,729,224,760
Buffalo, Rochester & Pittsburgh	19,875	1.09	83,172	2.12	-	103,047	967.98	2,695,800	5,641,493,600
Delaware & Hudson	16,581	1.16	243,132	2.60	11,964	271,677	1,512.60	4,579,935	11,115,079,344
Delaware, Lackawanna & Western	190	1.23	199,087	1.89	-	199,877	2,479.83	7,191,507	19,958,929,896
Detroit & Mackinac	479	.55	61,692	.97	*2,656	64,889	307.44	928,311	510,161,256
Detroit & Toledo Shore Line	-	-	17,162	2.10	*1,163	18,325	153.08	478,914	655,215,000
Erie (Inc. Chgo. & Erie)	3,267	.87	1,009,499	2.12	-	1,018,766	5,095.86	14,510,352	42,344,923,808
Grand Trunk Western	189,449	1.11	177,742	1.54	-	367,191	1,925.10	6,267,425	8,334,396,200
Lehigh & Hudson River	160	1.08	8,593	1.93	* 205	8,958	138.31	345,300	784,091,176
Lehigh & New England	1,120	.86	35,739	2.05	409	37,268	305.20	905,945	1,032,854,472
Lehigh Valley	-	-	200,967	1.85		200,967	3,129.41	9,269,120	16,802,336,848
Monongahela	47,845	1.64	5,906	2.31	-	53,751	249.62	711,760	1,197,444,344
Montour	3,601	1.76	16,614	2.21	-	20,215	78.06	218,568	370,357,000
New Jersey & New York	-	-	9,534	1.91	-	9,534	57.05	164,304	340,831,552
New York Central R.R. Co.	94,819	.99	2,468,579	1.90	*15,565	2,578,963	23,054.40	72,201,936	172,352,184,776
New York, Chicago & St.Louis	1,173	1.20	355,734	1.88	*(S) 50	356,957	2,641.19	8,499,400	17,990,900,760
New York, Ontario & Western	1,064	1.06	107,048	1.73	-	108,112	911.64	2,596,065	3,812,309,960
New York, Susquehanna & Western	281	1.56	41,688	1.85	-	41,969	241.17	694,570	724,255,584
Pere Marquette	590	.90	536,228	1.75	-	536,618	b 3,190.45	c 8,422,788	11,247,905,784
Pittsburgh & Lake Erie	2,169	.98	57,010	2.49	-	59,179	958.21	2,863,842	5,582,510,440
Pittsburg & Shawmut	20,506	1.19	-	-	47	20,563	129.51	359,465	271,413,648
Pittsburgh & West Virginia	16,620	1.63	-	-	-	16,620	164.37	447,673	505,495,576
Pittsburg, Shawmut & Northern	16,269	1.29	27,932	2.10	-	44,201	238.83	695,192	454,049,344
Ulster & Delaware	3,720	.91	6,252	1.72	-	9,972	158.12	432,100	257,560,893
Wabash	13,391	.88	581,834	1.45	-	595,225	3,360.00	10,598,396	24,273,545,734

TABLE A

CROSS-TIES LAID IN REPLACEMENT - CLASS 1 STEAM ROADS IN UNITED STATES

Calendar Year Ended December 31, 1930

Sheet 2 of 5

Road	Wooden ties untreated (U)		Wooden ties Treated (T)		Ties other than wood (S) and second-hand ties re-applied	Total Ties Applied	Miles of maintained tracks (Item 24)	Estimated total cross-ties in all maintained tracks (Item 25)	Equated gross ton-miles d
	Number	Average Cost	Number	Average Cost					
1	2	3	4	5	6	7	8	9	10
CENTRAL EASTERN REGION:									
Akron, Canton & Youngstown	53,990	$1.78	-	$ -	-	53,990	215.83	621,734	446,878,040
Atlantic City	-	-	33,823	2.11	-	33,823	309.94	875,425	885,168,416
Baltimore & Ohio	3,394	1.06	1,186,370	1.65	-	1,189,764	9,766.86	27,967,565	69,163,155,808
Bessemer & Lake Erie	36,432	1.67	83,672	2.35	2,333	122,437	519.09	1,645,302	3,966,516,384
Buffalo & Susquehanna	67,076	1.45	-	-	-	67,076	299.89	845,631	450,193,960
Central R.R. of New Jersey	-	-	126,505	1.66	-	126,505	1,526.94	4,295,843	10,668,327,560
Chicago & Eastern Illinois	183	1.25	155,511	1.50	-	155,694	1,547.92	4,799,634	7,551,686,104
Chicago & Illinois Midland	399	.88	19,532	1.62	-	19,931	158.32	477,509	744,151,792
Chicago, Indianapolis & Louisville	2,442	.89	136,901	1.34	*2,931	142,274	892.85	2,747,430	4,895,716,192
Detroit, Toledo & Ironton	17,726	.77	80,100	1.83	-	97,826	656.79	1,891,556	2,039,199,631
Elgin, Joliet & Eastern	-	-	209,862	1.56	(*2,713) (*(S) 157)	212,732	930.33	2,872,530	3,770,001,224
Illinois Terminal	8,979	.86	60,675	1.46	*4,213	73,867	739.21	2,007,000	1,496,143,408
Long Island	14,423	1.25	97,391	1.96	-	111,814	865.50	2,428,293	8,609,230,024
Missouri-Illinois	20,890	.78	27,367	1.19	-	48,257	245.12	756,500	339,557,568
Pennsylvania R.R. (Incl.W.J.& S.S.)	116,494	1.29	2,704,870	1.85	-	2,821,364	22,817.34	64,090,459	168,073,213,440
Reading Company	175	.96	430,904	1.80	-	431,079	3,136.68	8,953,894	20,909,561,312
Staten Island Rapid Transit	-	-	7,542	2.02	-	7,542	103.67	284,637	-
Western Maryland	120,005	1.12	132,070	1.53	-	252,075	1,224.60	3,526,859	5,520,776,432
Wheeling & Lake Erie	62,660	1.22	88,819	1.71	-	151,479	884.28	2,656,530	3,764,726,376
POCAHONTAS REGION:									
Chesapeake & Ohio (Incl. H.V.)	29,885	.83	881,063	1.40	-	910,948	5,272.95	16,236,073	53,994,344,816
Norfolk & Western	5,436	.63	761,159	1.41	-	766,595	4,355.94	13,503,414	39,123,180,752
Richmond, Fredericksburg & Potomac	152,250	1.14	-	-	*1,101	153,351	379.67	1,087,100	3,800,900,096
Virginian	154,031	.78	131,280	1.45	*358	285,669	834.22	2,628,869	5,970,894,920
SOUTHERN REGION:									
Alabama Great Southern	42,024	1.04	149,303	1.48	-	191,327	560.13	1,723,569	2,938,639,056
Atlanta & West Point	512	.91	32,473	1.29	-	32,985	b 166.64	c 439,930)	1,408,973,712
Western Ry. of Alabama	529	.88	49,176	1.29	-	49,705	185.40	555,555)	
Atlanta, Birmingham & Coast	91,351	1.01	102,771	1.26	-	194,122	800.37	2,302,935	1,669,421,584
Atlantic Coast Line	691,215	1.01	813,411	1.16	-	1,504,626	6,897.17	20,033,084	23,791,100,960
Central of Georgia	16,163	.79	352,694	.91	-	368,857	2,563.68	7,151,600	8,360,729,696
Charleston & Western Carolina	123,222	1.19	-	-	-	123,222	447.47	1,240,591	800,103,584
Cincinnati, New Orleans & Tex. Pac.	51,304	.98	176,271	1.64	-	227,575	759.39	2,346,913	7,581,970,032
Clinchfield	172,724	.88	19,737	1.53	-	192,461	403.63	1,229,367	2,190,345,344
Columbus & Greenville	26,552	.87	58,719	1.43	-	85,271	205.30	650,390	412,486,352
Florida East Coast	42,852	1.01	11,535	1.55	-	54,387	1,530.21	4,392,505	4,486,045,200
Georgia R.R.	2,209	1.30	107,611	1.35	-	109,820	440.08	1,319,381	1,613,703,408

TABLE A

CROSS-TIES LAID IN REPLACEMENT - CLASS 1 STEAM ROADS IN UNITED STATES

Calendar Year Ended December 31, 1930

Road	Wooden ties untreated (U)		Wooden ties Treated (T)		Ties other than wood (S) and second-hand ties re-applied	Total Ties Applied	Miles of maintained tracks (Item 24)	Estimated total cross-ties in all maintained tracks (Item 25)
	Number	Average Cost	Number	Average Cost				
1.	2.	3.	4.	5.	6.	7.	8.	9.
SOUTHERN REGION (CONT'D)								
Georgia & Florida	110,578	$ .73	-	$ -	-	110,578	512.93	1,384,911
Georgia, Southern & Florida	105,052	1.01	11,680	1.40	-	116,732	472.84	1,473,918
Gulf & Ship Island	5,234	1.38	110,978	1.08	-	116,212	362.97	1,121,387
Gulf, Mobile & Northern	34,234	.72	111,751	1.10	-	145,985	684.04	2,180,928
Illinois Central	46,309	1.28	1,237,491	1.16	-	1,283,800	7,970.72	24,337,886)
Yazoo & Mississippi Valley	18,511	1.26	510,993	1.24	-	529,504	2,238.36	6,973,265)
Louisville & Nashville	199,450	.73	1,314,748	1.70	-	1,514,198	7,571.75	21,085,359
Mississippi Central	1,526	.78	33,268	1.16	-	34,794	170.24	536,168
Mobile & Ohio	462,039	.87	2,197	1.24	-	464,236	1,286.42	4,075,370
Nashville, Chattanooga & St.Louis	6,287	.56	461,175	1.37	-	467,462	1,581.24	4,697,244
New Orleans & Northeastern	8,720	1.06	70,399	1.31	-	79,119	289.61	893,562
New Orleans Great Northern	14,882	.73	53,250	1.11	-	68,132	290.73	930,329
Norfolk Southern	335,982	.88	-	-	-	335,982	1,096.43	3,115,466
Northern Alabama	53,420	.99	-	-	-	53,420	138.90	439,248
Seaboard Air Line	989,947	.99	311,951	1.03	-	1,301,898	5,723.90	17,774,300
Southern Ry.	2,265,860	.96	881,862	1.44	-	3,147,722	3,967.55	28,339,403
Tennessee Central	73,748	.75	36,422	1.82	-	110,170	355.15	1,099,900
NORTHWESTERN REGION:								
Chicago & North Western	60,728	.74	2,140,451	1.18	-	2,201,179	12,707.98	36,797,767
Chicago Great Western	78,594	.93	354,279	1.21	-	432,873	1,963.52	5,741,180
Chicago, Milwaukee, St.Paul & Pacific	733,871	.67	2,507,817	1.20	-	3,241,688	15,115.15	43,843,322
Chicago, St.Paul, Minneapolis & Omaha	170,955	.64	357,399	1.44	-	528,354	2,365.93	7,010,592
Duluth, Missabe & Northern	52,253	.78	159,102	1.95	-	211,355	1,215.13	3,641,637
Duluth, South Shore & Atlantic	159,937	.76	-	-	-	159,937	680.00	2,035,757
Duluth, Winnipeg & Pacific	57,684	.76	-	-	-	57,684	217.21	651,600
Great Northern	160,106	.59	1,770,934	1.23	*47,061	1,978,101	10,182.23	32,251,676
Green Bay & Western	85,846	.87	-	-	-	85,846	290.27	812,756
Lake Superior & Ishpeming	53,257	.72	-	-	-	53,257	231.64	694,920
Minneapolis & St. Louis	117,255	.92	103,194	1.39	-	220,449	1,813.81	5,461,422
Minneapolis, St.Paul & Sault Ste. Marie	504,869	.77	648,517	1.57	-	1,153,386	5,192.86	15,280,845
Northern Pacific	72,328	.62	1,061,592	1.30	70	1,133,990	9,121.00	26,473,834
Oregon-Washington R.R.& Nav.Co.	515	1.33	371,765	.98	-	372,280	2,235.39	6,496,855
Spokane International	67,840	.56	-	-	-	67,840	194.71	548,738
Spokane, Portland & Seattle	2,831	.75	191,252	1.31	-	194,083	661.07	1,903,088

TABLE A

CROSS-TIES LAID IN REPLACEMENT - CLASS 1 STEAM ROADS IN UNITED STATES

Calendar Year Ended December 31, 1930

Road	Wooden ties untreated (U) Number	Wooden ties untreated (U) Average Cost	Wooden ties treated (T) Number	Wooden ties treated (T) Average Cost	Ties other than wood (S) and second-hand ties re-applied	Total Ties Applied	Miles of maintained tracks (Item 24)	Estimated total cross-ties in all maintained tracks (Item 25)
1.	2.	3.	4.	5.	6.	7.	8.	9.
CENTRAL WESTERN REGION:								
Atchison, Topeka & Santa Fe	6,349	$ .95	2,516,004	$1.38	-	2,522,353	14,511.29	44,070,788)
Panhandle & Santa Fe	-	-	303,580	1.42	-	303,580	2,167.57	6,466,705)
Bingham & Garfield	3,611	1.25	9,037	2.42	-	12,648	79.93	255,760
Chicago & Alton	443,757	1.12	647	1.06	*5,216	449,620	1,752.07	4,925,499
Chicago, Burlington & Quincy	-	-	1,952,516	1.29	*36,939	1,991,455	12,934.60	39,942,046
Chicago, Rock Island & Pacific	a 5,477	.43	a 1,256,829	1.10	-	1,262,306	9,848.12	29,557,625)
Chicago, Rock Island & Gulf	110	.41	133,955	1.60	*3,174	137,239	723.14	2,187,910)
Colorado & Southern	53,592	.45	118,095	1.59	*582	172,269	1,228.44	3,717,419
Denver & Rio Grande Western	7,339	.87	605,352	1.20	b 189,385	802,076	3,502.94	10,896,587
Denver & Salt Lake	41,324	1.16	3,771	1.71	-	45,095	325.54	979,620
Fort Worth & Denver City	-	-	151,773	1.55	-	151,773	850.59	2,572,080
Los Angeles & Salt Lake	-	-	195,737	1.65	*340	196,077	1,487.75	4,130,453
Nevada Northern	32,234	.96	-	-	-	32,234	191.04	546,293
Northwestern Pacific	147,750	.76	-	-	-	147,750	547.08	1,608,488
Oregon Short Line	208	.84	506,376	1.31	-	506,584	3,355.00	9,315,007
Quincy, Omaha & Kansas City	-	-	50,416	1.46	-	50,416	263.19	886,417
St. Joseph & Grand Island	40,912	1.35	1,252	1.75	-	42,164	335.48	994,586
San Diego & Arizona	22,286	1.21	115	2.49	-	22,401	169.25	499,249
Southern Pacific Co.- Pacific Lines	443,045	1.08	1,671,792	1.26	*4,740	2,119,578	12,903.76	37,776,337
Toledo Peoria & Western	32,029	1.11	10,713	1.54	*377	43,119	275.05	871,358
Union Pacific	260	1.05	732,002	1.37	-	732,262	5,972.00	16,858,200
Utah Ry.	10,083	.61	10,672	2.08	-	20,755	88.59	230,354
Western Pacific	453,970	.83	22	1.31	-	453,992	1,541.80	3,923,765
SOUTHWESTERN REGION:								
Burlington-Rock Island	-	-	141,757	1.02	-	141,757	354.51	1,110,680
Fort Smith & Western	72,992	.65	-	-	-	72,992	234.82	734,500
Fort Worth & Rio Grande	9,687	.96	27,975	1.48	-	37,662	245.49	777,712
Gulf Coast Lines:								
Beaumont, Sour Lake & Western	-	-	30,717	1.30	*15	30,732	142.04	423,300)
New Orleans, Texas & Mexico	-	-	30,374	1.31	-	30,374	225.06	698,600)
St.Louis, Brownsville & Mexico	-	-	115,348	1.09	-	115,348	731.58	2,217,900)
Gulf, Colorado & Santa Fe	8,691	.53	474,599	1.21	-	483,290	2,589.56	8,191,039
International-Great Northern	4,356	.59	296,909	1.15	-	301,265	1,474.72	4,429,600
Kansas City Southern	683	.63	194,975	1.21	-	195,658	1,156.28	3,629,182)
Texarkana & Fort Smith	27	.65	22,585	1.20	-	22,612	161.03	502,098)
Kansas, Oklahoma & Gulf	713	.82	43,534	1.41	-	44,247	378.58	1,208,657
Louisiana & Arkansas	143,491	.84	105,774	1.10	-	249,265	735.40	2,321,727
Louisiana, Arkansas & Texas	81,193	.90	5,453	1.27	-	86,646	251.64	741,888
Midland Valley	1,811	.69	68,412	1.38	-	70,223	486.66	1,369,756
Missouri & North Arkansas	91,338	.70	-	-	-	91,338	365.30	1,138,718

TABLE A

CROSS-TIES LAID IN REPLACEMENT - CLASS 1 STEAM ROADS IN UNITED STATES

Calendar Year Ended December 31, 1930

Sheet 5 of 5

Road	Wooden ties untreated (U)		Wooden ties treated (T)		Ties other than wood (S) and second-hand ties re-applied	Total Ties Applied	Miles of maintained tracks (Item 24)	Estimated total cross-ties in all maintained tracks (Item 25)	Equated gross ton-miles d
	Number	Average Cost	Number	Average Cost					
1	2.	3.	4.	5.	6.	7.	8.	9.	10.
SOUTHWESTERN REGION (CONT'D)									
Missouri-Kansas-Texas Lines:									
Missouri-Kansas-Texas	-	-	389,581	$1.33	-	389,581	2,514.30	7,295,600)	16,618,620,568
Missouri-Kansas-Texas of Texas	-	-	259,831	1.33	-	259,831	1,704.72	5,411,200)	
Missouri Pacific	480,277	$ .83	1,558,246	1.14	-	2,038,523	9,394.16	29,151,900	48,857,522,416
Oklahoma City-Ada-Atoka	56,431	.79	6,491	1.52	-	62,922	155.90	488,544	-
St.Louis - San Francisco	253,269	.78	918,117	1.22	-	1,171,386	6,974.18	21,655,606	24,499,540,728
St.Louis, San Francisco & Texas	4,672	.86	33,380	1.36	-	38,052	254.67	806,795	409,049,936
St.Louis Southwestern	5,807	.45	276,422	1.21	*7,557	289,786	1,084.85	3,443,154)	8,036,658,496
St.Louis Southwestern of Texas	-	-	143,224	1.23	*29,171	172,395	969.55	3,055,566)	
San Antonio, Uvalde & Gulf	-	-	87,322	1.28	*2,031	89,353	363.15	1,048,300	603,490,088
Texas & New Orleans	167,069	1.15	876,705	1.32	-	1,043,774	6,020.84	16,526,286	20,728,074,552
Texas & Pacific	486	.75	431,388	1.14	-	431,874	2,538.90	7,992,574	15,517,239,544
Texas Mexican	214	.60	55,444	1.41	-	55,658	206.55	594,818	244,495,560
Wichita Falls & Southern	437	.92	48,756	1.27	-	49,193	198.99	656,667	178,184,112
Wichita Valley		-	60,586	1.33	-	60,586	296.95	890,120	224,922,800
CANADIAN ROADS:									
Canadian National Railways	4,665,666	$0.78	1,772,587	$1.72	-	6,438,253	31,819.17	90,215,210	-
Grand Trunk Lines in New England) Grand Trunk Western Railway) Duluth, Winnipeg & Pacific Ry.)	4,535,934	0.78	1,772,587	1.72	-	6,308,521	31,251.00	88,565,520	-
Temiskaming & Northern Railway	129,732	0.76	-	-	-	129,732	568.17	1,547,690	-
Canadian Pacific Railway	1,319,062	0.76	3,292,458	1.77	-	4,611,520	20,943.00	58,845,360	-

* All second-hand.
a Includes second-hand ties.
b All tracks operated less trackage rights.
c Estimated by Bureau of Railway Economics on basis of 2,640 ties to the mile.
d Maishaider formula.
n Indicates narrow-gauge ties.

NOTE: Compiled from Annual Reports of Class 1 Steam Roads to the Interstate Commerce Commission.

TABLE B

WOODEN CROSS-TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended December 31, 1930

NOTE: All figures are exclusive of bridge & switch ties

Sheet 1 of 5

Road	Miles of maintained track occupied by wooden cross-ties (Col.8-table A)	Average number of wooden cross-ties per mile of maintained track	Total number of wooden cross-ties renewed 1930	Average number of wooden cross-ties renewed per mile of maintained track	Weighted average cost per wooden cross-tie	Average cost of wooden cross-tie renewals per mile of maintained track	Average percentage of wooden cross-tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross-tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
NEW ENGLAND REGION:									
Bangor & Aroostook	846.46	2,878	214,218	253	$ .82	$207	8.8	2,035,775	$.103
Boston & Maine	3,987.04	2,703	941,578	236	1.63	385	8.7	4,289,942	.090
Canadian National Lines in N.E.	257.51	3,200	41,131	160	1.57	251	5.0	2,354,836	.106
Canadian Pacific Lines in Maine	213.71	2,890	66,484	320	1.24	397	11.1	5,459,077	.073
Canadian Pacific Lines in Vermont	123.25	3,128	38,519	313	1.32	413	10.0	5,405,123	.077
Central Vermont	562.65	3,203	137,081	244	1.75	427	7.3	4,697,175	.091
Maine Central	1,371.49	3,033	334,452	244	1.12	273	8.0	3,390,505	.080
New York Connecting	25.98	3,189	5,050	194	1.97	382	6.1	14,186,365	.027
New York, New Haven & Hartford	4,553.02	3,095	1,150,359	253	1.63	412	8.2	5,347,296	.077
Rutland	526.14	3,001	117,930	224	1.63	365	7.5	3,686,039	.099
GREAT LAKES REGION:									
Ann Arbor	419.12	3,000	62,095	148	1.53	226	4.9	4,125,846	.055
Buffalo, Rochester & Pittsburgh	967.98	2,785	103,047	106	1.92	204	3.8	5,888,110	.035
Delaware & Hudson	1,512.60	3,028	259,713	172	2.51	432	5.7	7,348,327	.059
Delaware, Lackawanna & Western	2,479.83	2,900	199,277	80	1.89	151	2.8	8,046,507	.019
Detroit & Mackinac	307.44	3,000	62,171	202	.96	194	6.7	1,008,851	.193
Detroit & Toledo Shore Line	153.08	3,129	17,162	112	2.10	235	3.6	4,345,538	.054
Erie (Including Chicago & Erie)	5,095.86	2,847	1,012,765	199	2.12	422	7.0	8,309,672	.051
Grand Trunk Western	1,925.10	3,256	367,191	191	1.32	252	5.9	4,324,137	.058
Lehigh & Hudson River	132.31	2,610	8,753	66	1.92	127	2.5	5,926,167	.021
Lehigh & New England	305.20	2,966	36,859	121	2.01	243	4.1	3,384,189	.072
Lehigh Valley	3,129.41	2,962	200,967	64	1.85	118	2.2	6,008,269	.020
Monongahela	249.62	2,861	53,751	215	1.71	368	7.6	4,797,069	.077
Montour	78.06	2,800	20,215	259	2.13	552	9.2	4,744,517	.116
New Jersey & New York	57.05	2,880	9,534	167	1.91	319	5.8	5,974,260	.054
New York Central R.R. Co.	23,054.40	3,132	2,563,398	111	1.87	208	3.6	7,475,891	.028
New York, Chicago & St.Louis	2,641.19	3,218	356,907	135	1.88	254	4.2	6,811,665	.037
New York, Ontario & Western	911.64	2,848	108,112	119	1.73	206	4.2	4,181,815	.049
New York, Susquehanna & Western	241.17	2,880	41,969	174	1.86	322	6.0	3,003,092	.107
Pere Marquette	b 3,190.45	2,640	536,618	168	1.75	294	6.4	5,525,498	.054
Pittsburgh & Lake Erie	958.21	2,989	59,179	62	2.43	151	2.1	5,885,978	.026
Pittsburg & Shawmut	129.51	2,776	20,506	158	1.19	188	5.7	2,095,696	.090
Pittsburgh & West Virginia	154.37	2,900	16,680	108	1.65	176	3.7	3,274,571	.053
Pittsburg, Shawmut & Northern	238.83	2,911	44,301	186	1.80	333	6.4	1,901,140	.175
Ulster & Delaware	158.12	2,733	9,972	63	1.42	89	2.3	1,686,895	.053
Wabash	3,360.00	3,154	595,225	177	1.43	253	5.6	7,224,270	.035

TABLE B

WOODEN CROSS-TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended December 31, 1930

NOTE: All figures are exclusive of bridge & switch ties

Sheet 2 of 5

Road	Miles of maintained track occupied by wooden cross-ties (Col. 8-Table A)	Average number of wooden cross-ties per mile of maintained track	Total number of wooden cross-ties renewed 1930	Average number of wooden cross-ties renewed per mile of maintained track	Weighted average cost per wooden cross-ties	Average cost of wooden cross-tie renewals per mile of maintained track	Average percentage of wooden cross-tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross-tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
CENTRAL EASTERN REGION:									
Akron, Canton & Youngstown	215.88	2,880	53,990	250	$1.78	$445	8.7	2,070,030	$.215
Atlantic City	309.94	2,884	33,823	109	2.11	230	3.9	2,855,935	.081
Baltimore & Ohio	9,766.86	2,864	1,189,764	122	1.65	201	4.3	7,061,412	.028
Bessemer & Lake Erie	519.09	3,170	120,104	231	2.20	508	7.3	7,641,288	.067
Buffalo & Susquehanna	299.69	2,880	67,076	224	1.45	325	7.9	1,501,197	.216
Central R.R. of New Jersey	1,526.94	2,815	126,505	83	1.88	156	2.9	6,986,737	.022
Chicago & Eastern Illinois	1,547.68	3,101	155,694	101	1.50	152	3.2	4,878,918	.031
Chicago & Illinois Midland	158.32	3,016	19,931	126	1.60	202	4.2	4,700,302	.043
Chicago, Indianapolis & Louisville	898.65	3,077	159,343	156	1.33	207	5.1	5,463,846	.038
Detroit, Toledo & Ironton	656.79	2,880	97,886	149	1.64	244	5.2	3,104,797	.079
Elgin, Joliet & Eastern	930.33	3,088	209,862	226	1.56	353	7.3	4,052,327	.087
Illinois Terminal	739.21	2,706	69,654	94	1.38	130	3.5	2,023,976	.064
Long Island	865.50	2,806	111,614	129	1.87	241	4.6	9,947,117	.024
Missouri-Illinois	245.12	3,086	48,257	197	1.02	201	6.4	1,361,191	.145
Pennsylvania R.R. (Incl. W.J.& S.S.)	23,317.34	2,808	2,891,364	124	1.83	227	4.4	8,368,852	.027
Reading Company	3,156.68	2,855	431,079	137	1.80	247	4.8	6,666,144	.037
Staten Island Rapid Transit	105.67	2,746	7,742	73	2.02	147	2.6	-	-
Western Maryland	1,224.60	2,880	252,075	206	1.33	274	7.1	4,514,761	.061
Wheeling & Lake Erie	884.88	3,015	151,479	171	1.51	258	5.7	4,257,392	.061
POCAHONTAS REGION:									
Chesapeake & Ohio (Inc. H.V.)	5,272.95	3,079	910,946	173	1.38	239	5.6	10,259,874	.023
Norfolk & Western	4,355.94	3,100	766,595	176	1.41	248	5.7	8,961,570	.028
Richmond, Fredericksburg & Potomac	579.67	2,853	232,250	401	1.14	457	14.0	10,011,062	.046
Virginian	834.22	3,151	285,311	342	1.09	373	10.9	7,157,458	.052
SOUTHERN REGION:									
Alabama Great Southern	560.15	3,086	191,327	342	1.37	469	11.1	5,246,352	.089
Atlanta & West Point	b 166.64	2,640	32,965	198	1.29	255	7.5)		
Western Ry. of Alabama	185.40	2,997	49,705	268	1.29	346	8.9)	4,002,320	.076
Atlanta, Birmingham & Coast	800.37	2,877	194,122	243	1.14	277	8.4	2,085,618	.133
Atlantic Coast Line	6,897.17	2,905	1,504,626	218	1.09	238	7.5	3,449,400	.069
Central of Georgia	2,563.68	2,790	368,857	144	.91	131	5.2	3,261,222	.040
Charleston & Western Carolina	447.47	2,772	123,222	275	1.19	327	9.9	1,966,844	.167
Cincinnati, New Orleans & Texas Pacific	759.39	3,091	227,575	300	1.49	447	9.7	9,984,290	.045
Clinchfield	403.63	3,046	192,461	477	.89	425	15.7	5,401,842	.078
Columbus & Greenville	205.30	3,168	85,271	415	1.25	519	13.1	2,009,188	.259
Florida East Coast	1,530.21	2,871	54,387	36	1.12	40	1.2	2,931,653	.014
Georgia R.R.	440.08	2,998	109,820	250	1.34	335	8.3	3,666,852	.091
Georgia & Florida	512.93	2,700	110,578	216	.73	157	8.0	912,455	.172
Georgia, Southern & Florida	472.84	3,117	116,732	247	1.05	259	7.9	3,478,356	.075

TABLE B

WOODEN CROSS-TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended December 31, 1930

NOTE: All figures are exclusive of bridge & switch ties

Sheet 5 of 5

Road	Miles of maintained track occupied by wooden cross-ties (Col.8-Table A)	Average number of wooden cross-ties per mile of maintained track	Total number of wooden cross-ties renewed 1930	Average number of wooden cross-ties renewed per mile of maintained track	Weighted average cost per wooden cross-ties	Average cost of wooden cross-tie renewals per mile of maintained track	Average percentage of wooden cross-tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross-tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
SOUTHERN REGION (CONT'D)									
Gulf & Ship Island	562.97	3,089	116,212	330	$1.10	$552	10.4	1,799,857	$.195
Gulf, Mobile & Northern	684.04	3,200	145,965	213	1.01	215	6.7	3,065,615	.070
Illinois Central	7,270.72	3,053	1,235,800	161	1.16	187	5.3)	5,908,066	.036
Yazoo & Mississippi Valley	2,238.36	3,115	529,504	237	1.24	294	7.6)		
Louisville & Nashville	7,571.75	2,786	1,514,198	200	1.57	314	7.2	5,716,287	.055
Mississippi Central	170.24	3,149	34,794	204	1.16	237	6.5	1,648,216	.144
Mobile & Ohio	1,286.42	3,168	464,236	361	.88	318	11.4	4,235,613	.075
Nashville, Chattanooga & St.Louis	1,381.24	2,971	407,462	296	1.36	403	10.0	4,514,359	.089
New Orleans & Northeastern	289.61	3,085	79,119	273	1.28	349	8.9	5,863,975	.060
New Orleans Great Northern	290.75	3,200	68,158	234	1.02	239	7.3	2,296,462	.105
Norfolk Southern	1,096.43	2,841	335,982	306	.88	269	10.8	1,782,919	.151
Northern Alabama	138.90	3,162	53,420	385	.99	381	12.2	2,006,816	.189
Seaboard Air Line	5,723.96	3,105	1,301,898	227	1.00	227	7.3	3,369,981	.068
Southern Ry.	8,967.55	3,160	3,147,722	351	1.10	386	11.1	4,684,996	.082
Tennessee Central	355.15	3,097	110,170	310	1.10	341	10.0	2,334,903	.146
NORTHWESTERN REGION:									
Chicago & North Western	12,707.98	2,896	2,201,179	173	1.16	202	6.0	3,705,323	.054
Chicago Great Western	1,965.52	2,924	432,873	220	1.16	255	7.5	4,918,975	.052
Chicago,Milwaukee, St.Paul & Pacific	15,115.15	2,901	3,241,688	214	1.08	231	7.4	3,559,003	.065
Chicago,St.Paul, Minneapolis & Omaha	2,365.93	2,963	528,554	223	1.18	263	7.5	3,367,586	.078
Duluth, Missabe & Northern	1,215.13	2,997	211,355	174	1.66	289	5.8	2,997,451	.097
Duluth, South Shore & Atlantic	680.00	2,994	159,937	235	.76	179	7.9	1,579,850	.114
Duluth, Winnipeg & Pacific	217.21	3,000	57,684	266	.76	202	8.9	3,036,773	.066
Great Northern	11,182.23	3,167	1,931,040	190	1.18	224	6.0	3,481,016	.064
Green Bay & Western	290.27	2,800	85,846	296	.87	258	10.6	1,568,641	.163
Lake Superior & Ishpeming	231.64	3,000	53,257	230	.72	166	7.7	962,466	.172
Minneapolis & St.Louis	1,813.81	3,011	220,449	122	1.14	139	4.0	2,447,752	.057
Minneapolis, St.Paul & Sault Ste. Marie	5,192.86	2,943	1,153,386	222	1.22	271	7.5	2,582,840	.105
Northern Pacific	9,121.00	2,903	1,133,920	124	1.26	156	4.3	3,044,541	.051
Oregon-Washington R.R. & Nav. Co.	2,235.39	2,906	372,280	167	.98	164	5.7	3,245,055	.050
Spokane International	194.71	2,818	67,840	346	.56	195	12.4	1,228,953	.160
Spokane, Portland & Seattle	661.07	2,879	194,083	294	1.31	385	10.8	3,738,236	.103
CENTRAL WESTERN REGION:									
Atchison, Topeka & Santa Fe	14,511.29	3,037	2,322,353	160	1.38	221	5.3)	4,540,647	.048
Panhandle & Santa Fe	2,167.57	2,983	303,580	140	1.42	199	4.7)		
Bingham & Garfield	79.93	3,200	12,648	158	2.08	329	4.9	483,006	.681
Chicago & Alton	1,752.07	2,811	444,404	254	1.12	284	9.0	5,215,087	.054
Chicago, Burlington & Quincy	12,964.60	3,088	1,958,518	151	1.29	195	4.9	4,065,600	.048
Chicago, Rock Island & Pacific	9,846.12	3,001	1,262,306	128	1.10	141	4.3)		
Chicago, Rock Island & Gulf	723.14	3,026	134,065	185	1.60	296	6.1)	4,250,048	.036

TABLE B

WOODEN CROSS-TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended December 31, 1930

NOTE: All figures are exclusive of bridge & switch ties

Sheet 4 of 5

Road	Miles of maintained track occupied by wooden cross-ties (Col, 8-Table A)	Average number of wooden cross-ties per mile of maintained track	Total number of wooden cross-ties renewed 1930	Average number of wooden cross-ties renewed per mile of maintained track	Weighted average cost per wooden cross-ties	Average cost of wooden cross-tie renewals per mile of maintained track	Average percentage of wooden cross-tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross-tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
CENTRAL WESTERN REGION (CONT'D)									
Colorado & Southern	1,888.44	3,086	171,687	140	$1.09	$153	4.6	2,708,122	$.056
Denver & Rio Grande Western	3,502.94	3,111	618,691	175	1.80	210	5.6	3,004,475	.070
Denver & Salt Lake	326.54	3,000	45,095	138	1.28	168	4.6	1,972,677	.085
Fort Worth & Denver City	850.59	3,024	151,773	178	1.36	240	5.9	3,903,701	.062
Los Angeles & Salt Lake	1,487.75	2,776	195,737	132	1.63	215	4.7	5,546,567	.039
Nevada Northern	191.04	2,870	32,234	169	.96	162	5.9	669,389	.242
Northwestern Pacific	547.08	2,940	147,750	270	.76	205	9.2	2,294,461	.089
Oregon Short Line	3,355.00	2,776	506,584	151	1.31	198	5.4	3,518,281	.056
Quincy, Omaha & Kansas City	263.19	3,140	50,416	192	1.46	280	6.1	928,461	.301
St. Joseph & Grand Island	335.48	2,965	42,164	125	1.34	169	4.2	3,592,810	.047
San Diego & Arizona	169.25	2,950	22,401	132	1.21	160	4.5	1,193,196	.135
Southern Pacific Co.- Pacific Lines	12,903.76	2,928	2,114,838	164	1.21	198	5.6	5,110,956	.039
Toledo, Peoria & Western	275.05	3,168	42,742	155	1.22	189	4.9	2,000,947	.095
Union Pacific	5,972.00	2,823	732,262	183	1.37	169	4.3	8,094,609	.021
Utah Ry.	88.59	2,600	20,755	234	1.37	321	9.0	4,503,740	.071
Western Pacific	1,341.60	2,924	453,992	338	.83	281	11.6	5,887,909	.053
SOUTHWESTERN REGION:									
Burlington-Rock Island	354.51	3,135	141,757	400	1.02	328	12.8	1,815,892	.855
Fort Smith & Western	234.82	3,128	72,992	311	.65	202	9.9	1,869,186	.108
Fort Worth & Rio Grande	245.49	3,168	37,662	153	1.35	207	4.8	1,252,253	.165
Gulf Coast Lines:									
Beaumont, Sour Lake & Western	142.04	2,980	30,717	216	1.30	281	7.3)		
New Orleans, Texas & Mexico	225.06	3,060	50,374	224	1.31	293	7.3)	4,581,964	.046
St.Louis, Brownsville & Mexico	731.58	3,032	115,348	158	1.09	172	5.2)		
Gulf, Colorado & Santa Fe	2,529.66	3,238	483,290	191	1.19	227	5.9	3,620,226	.063
International-Great Northern	1,474.72	3,004	301,265	204	1.15	235	6.8	3,931,311	.060
Kansas City Southern	1,158.28	3,133	195,658	169	1.21	204	5.4)		
Texarkana & Fort Smith	161.03	3,118	22,612	140	1.20	168	4.5)	4,918,633	.041
Kansas, Oklahoma & Gulf	378.58	3,193	44,247	117	1.40	164	3.7	2,429,795	.067
Louisiana & Arkansas	735.40	3,157	249,265	339	.95	322	10.7	2,429,356	.133
Louisiana, Arkansas & Texas	251.84	3,200	86,646	374	.92	344	11.7	1,250,568	.276
Midland Valley	426.65	3,211	70,223	165	1.36	224	5.1	1,579,854	.142
Missouri & North Arkansas	365.30	3,117	91,332	250	.70	175	8.0	1,661,689	.106
Missouri-Kansas-Texas Lines:									
Missouri-Kansas-Texas	2,314.30	3,152	389,581	168	1.33	223	5.3)		
Missouri-Kansas-Texas of Texas	1,704.72	3,174	259,831	152	1.33	202	4.8)	4,134,993	.052
Missouri Pacific	9,394.16	3,103	2,038,523	217	1.07	238	7.0	5,179,550	.045
Oklahoma City-Ada-Atoka	155.90	3,134	62,922	404	.86	347	12.9	-	-

TABLE B

WOODEN CROSS-TIES LAID IN REPLACEMENT (TREATED & UNTREATED) ON LEADING RAILROADS IN THE UNITED STATES

Calendar Year Ended December 31, 1930

Sheet 5 of 5

NOTE: All figures are exclusive of bridge & switch ties

Road	Miles of maintained track occupied by wooden cross-ties (Col.8-Table A)	Average number of wooden cross-ties per mile of maintained track	Total number of wooden cross-ties renewed 1930	Average number of wooden cross-ties renewed per mile of maintained track	Weighted average cost per wooden cross-ties	Average cost of wooden cross-tie renewals per mile of maintained track	Average percentage of wooden cross-tie renewals	Equated gross ton miles per mile of maintained track	Cost of wooden cross-tie renewals per thousand equated gross ton-miles
1	2	3	4	5	6	7	8	9	10
SOUTHWESTERN REGION:									
St.Louis-San Francisco	6,974.18	3,105	1,171,586	168	$1.13	$190	5.4	3,518,898	$.054
St.Louis, San Francisco & Texas	254.67	3,168	38,058	149	1.30	194	4.7	1,606,196	.121
St.Louis Southwestern	1,084.65	3,174	282,289	260	1.20	318	8.2)	3,911,963	.064
St.Louis Southwestern of Texas	969.53	3,152	143,224	148	1.23	182	4.7)		
San Antonio, Uvalde & Gulf	363.15	2,887	87,322	240	1.28	307	8.3	1,661,820	.185
Texas & New Orleans	6,020.84	2,745	1,043,774	173	1.29	223	6.3	3,442,721	.065
Texas & Pacific	2,538.90	3,148	431,874	170	1.14	194	5.4	6,111,796	.032
Texas Mexican	206.63	2,880	55,658	269	1.41	379	9.4	1,163,816	.330
Wichita Falls & Southern	198.99	3,300	49,193	247	1.27	314	7.5	865,290	.362
Wichita Valley	296.93	2,998	60,586	204	1.33	271	6.8	757,494	.359

Col. 3 derived by dividing Col. 9 Table A by Col. 8 of same table.
Col. 4 is total of columns 2 and 4 of table A.
Col. 5 derived by dividing the totals of Columns 2 and 4 of table A by Col.8 of same table.
Col. 6 is weighted average of costs shown in columns 3 and 5 of table A.
b All tracks operated less trackage rights.
NOTE: Compiled from Annual Reports of Class 1 Steam Roads to the Interstate Commerce Commission.

Road	2	3	4	5	6	7	8	9	10
CANADIAN ROADS:									
Canadian National Railways	31,819.17	2,835	6,438,253	202	$1.04	$210	7.1	-	-
Grand Trunk Lines in New England) Grand Trunk Western Railway) Duluth, Winnipeg & Pacific Railway)	31,251.00	2,834	6,308,521	202	1.04	211	7.1	-	-
Temiskaming & Northern Railway	568.17	2,900	129,732	229	0.76	174	7.8	-	-
Canadian Pacific Railway	20,943.00	2,810	4,611,520	220	1.48	327	7.9	-	-

Appendix D

(7) ECONOMICS OF USE OF 8½-FOOT AND 9-FOOT TIES AS COMPARED WITH 8-FOOT TIES

J. E. King, Chairman, Sub-Committee; W. C. Bolin, E. E. Chapman, H. R. Clarke, R. L. Cooke, H. C. Munson, L. J. Riegler.

Thirty-eight railways responded to a questionnaire. These roads, representing all sections of the United States and Canada, present a reasonably accurate view of the situation in general. The roads and practices prevalent are as shown in the appended tabulation.

The data obtained indicates that the effect on cost of track maintenance through heavier axle loading and increased traffic density governs the change to ties longer than eight feet.

From the data available, it seems that many railways have found it necessary to increase the bearing capacity of ties when the axle loadings approximate 70,000 lb., or when the amount of traffic produces an equivalent effect on the track.

The increased bearing area has been secured in several ways, including increased length, wider ties, and increased number per rail. Regardless of the method employed it is evident that the inter-relationship of a tie's three dimensions must be considered. This is clearly brought out in a reply received from one of the reporting roads:

"Coincidentally, with the use of the longer tie, greater cross-sectional dimensions have been demanded, the 8 to 10-inch width giving larger bearing area, and this together with the increased thickness to 7 inches, providing for increased stiffness as measured by the bending moment.

"Numerous efforts have been made from time to time to determine whether the result of experience was in harmony and co-ordination with theoretical determination, and in addition the information from service experimental trials has been brought into the study. Ever since the first Association of the International Railway Congress in Brussels in 1885 and up to the Congress of 1922 at Rome, the subject of strengthening the track to meet the increased demands of traffic has been before the association at every Congress.

"Several most able reports of theoretical studies and service trials have been before these Congresses, the work of Ast in particular being ranked as a classic on the subject.

"These works were carefully reviewed for the Berne Congress of 1910 by Herman Rosches, General Manager and Vice-President of the Board of the Aussig–Teplitz Railway, and he has shown in an exhaustive study that the short cross-ties have an unfavorable influence on the track when the traffic is heavy, and that both theory and experience have demonstrated conclusively that the long cross-tie is absolutely necessary for modern conditions, and should be about 10 inches wide and spaced not over 21 inches apart. When it is considered that these conclusions have been reached in the study with locomotive axle loads of about 40,000 lb., it can well be seen how the conclusion is much more forceful for our axle loads of 75,000 lb."

Quoting from another reply received by the Committee:

"In spite of these precautions we had centerbound track, indicating obviously that the ties were too short. This led us to a study of the length of ties that would be theoretically correct. We found that if the intersections of the load resultants through the rail with the center line of the tie were 4 feet 8½ inches apart, the theoretical length of the tie would be 8 feet. Since this condition cannot exist, and since these intersections must be over 4 feet 8½ inches apart (on standard gage) the theoretical tie must be over 8 feet long. There are so many variables which enter into the determination of the location of the resultant of the forces of the loads on the ties that a theoretical correct length can never be determined. However, it is quite evident that this length is over 8 feet 6 inches and under 9 feet, but more nearly 9 feet than 8 feet 6 inches."

The Committee has been able to secure data from one railway which shows a definite reduction in cost of maintaining line and surface following the adoption of a larger tie. On the majority of railways where such changes have been made, the transition has been made gradually and required considerable time. General economic conditions and methods of handling work before and after the period required for the change to take place have been so different that any attempt to place definite value is impractical. Quotations from report of the railway furnishing concrete evidence of a saving through the use of longer ties follows:

"*Size of Tie*	*Ties per Mile*	*Cost per Tie*	*Cost per Mile*
7″ × 9″ × 8½′	2816	1.50	$4224.00
6″ × 8″ × 8′	3168	1.10	3484.80

Excess cost of ties	$ 739.00
Excess annual cost (based on 15 year life)	49.28

Less: Annual cost of spikes and tie plates necessary for additional ties where 6″ × 8″ × 8′ ties are used; also labor applying ties and tie plates:

Spikes	Total cost 4 kegs @ $5.61	$22.44		
	Annual cost (10 yr. life)		$2.24	
Tie plates	Total cost 704 @ $0.22	154.88		
	Annual cost (15 yr. life)		10.32	
Applying ties	Total cost 352 @ $0.30	105.60		
	Annual cost (15 yr. life)		7.04	
Applying tie plates	Total cost 704 @ $0.01	7.04		
	Annual cost (15 yr. life)		.47	
				20.07
	Net annual additional cost			$ 29.21

"The net annual additional cost for the longer ties is $29.21; the increased bearing surface of the longer and wider ties is 1056 square feet, or an increase of 6 per cent.

"Using as a basis the cost of a section gang for an eight-mile section, is as follows:

1 foreman @ $125.00 per mo. × 12	$1500.00
6 laborers @ 28¼¢ × 8 × 300 days	4068.00
Total annual cost for section	$5568.00
Total annual cost per mile	696.00

"Time consumed in smoothing, lining, and draining track requires two-thirds of the total time, or an annual cost for these items of $464. With the increased bearing surface, 20 per cent, or $92.80, of this cost may be saved, which, after deducting the net annual additional cost by use of the longer tie, leaves a net annual saving of $63.59 per mile.

"When the change was begun in 1917 the 7″ × 9″ × 8½′ ties were inserted where the 6″ × 8″ × 8′ ties were removed with no change in spacing. It is the consensus of opinion of Supervisors and Division Engineer that to reduce the number of ties per rail length off-sets nearly all the benefits derived from additional width, thickness and length.

"Maintaining standard 6″ × 8″ × 8′ spacing with 7″ × 9″ × 8½′ ties not only provides 20 per cent more bearing area, but tends to reduce the girder span between edges of ties.

"With reference to the additional six inches of length; we require 31 per cent more board feet to get 12 per cent more area on a 7″ × 9″ × 8′ tie, and require 39 per cent more board feet to get 20 per cent more bearing area on the 7″ × 9″ × 8½′ tie.

"Both Road Supervisors who have the two kinds of ties on their districts favor the additional length as well as added thickness and width, claiming it is easier to hold line and surface with the larger tie, not only on curves, but on tangent track as well."

Attention is called to the fact that good track is not dependent upon ties alone, but upon the condition of rail, ballast, and drainage as well. The question of economic

track makeup has been reported on by the Special Committee on Stresses in Track, particularly in its report in the Proceedings, Vol. 21, page 645.

Conclusions presented by the Stresses in Track Committee are the result of comprehensive tests and detailed study of the action of ties under varying conditions of load, size of tie, length of tie, tie spacing, kind and depth of ballast, etc. From page 744 of Vol. 21, the following is quoted:

"An examination of the diagrams of depression and flexure brings out a variety of conditions. It will be observed that there is bending of tie in every case, though the form of the curve varies greatly. It is evident that there must be great differences in the way in which the bearing pressure varies along the length of the tie under the conditions to which ties are subjected. In many ties there is play between the tie and its bed at one point or another, or even over a considerable portion of its length, which not only gives unevenness of track depression, but increases the intensity of bearing pressure at some point along the tie, and gives added bending stresses in the tie. It is clear that there is a great variety of distribution of bending moments along the tie—the bending moment at a section at the middle of the tie may be positive in one tie and negative in another."

It is concluded that, although conditions vary greatly, it is possible to determine the saving effected by the use of longer ties in place of 8-foot ties. An increase in the length of the tie, up to a certain point, increases the effective bearing area, and has a beneficial effect upon the distribution of pressure, which fact should effect savings.

The Committee is confident that further data can be secured which will permit establishing reasonably correct limits within which the different lengths and sizes of ties may be used most economically.

Appendix E

(9) METHODS OF DATING CROSS-TIES

C. W. Greene, Chairman, Sub-Committee; E. E. Chapman, E. L. Crugar, H. R. Duncan, F. C. Krell, K. G. Williams.

Forty-one replies to seventy questionnaires sent to railways in the United States and Canada may be summarized as follows:

	Number of Railroads	*Miles of Maintained Tracks Occupied by Cross Ties*
Using dating nails on all ties	24	11,802,012
Using dating nails on ties in test sections only	2	1,526,060
Using dating nails in treated ties only	1	137,362
Branding dates on all ties	4	481,322
Stamping dates on all ties	1	1,067,362
Using no nails nor brands of any kind	9	2,868,459

Fourteen railways are placing dating nails on ties, inside rails (not centered).
Six railways are placing dating nails on ties inside rails (centered on tie).
Two railways are placing dating nails on ties outside rails, various locations.
One railway has no definite location for dating nails.
Twenty-four railways are placing dating nails after installation of ties in track.
Eight railways are placing dating nails before installation of ties in track.
Sixteen railways are using dating nails manufactured according to A.R.E.A. specifications.
Eight railways are using dating nails under various specifications.
All branding and stamping of ties is done on the ends of the ties.
A general practice of branding dates on ends of ties in addition to use of dating nails is apparent where adzing and boring machines are in use.

Railroad	Miles of Maintained Tracks Occupied by Cross Ties	Ties Per Mile 8'0"	Ties Per Mile 8'6"	Ties Per Mile 9'0"	Maximum Axle Load (lbs.)	Equated Gross Ton Miles
		EASTERN GROUP				
Baltimore & Ohio	10,673.62		2980		69,830	78,413,846,696
Bessemer & Lake Erie	519.59		3250		75,810	4,834,788,888
Boston & Maine	3,789.39		3115		62,900	17,906,982,552
Chicago & Alton	1,642.91	3200			52,000	10,031,770,176
Chicago, Ind. & Louisvl.	891.65	3250			68,000	5,678,371,904
C. C. C. & St. L.	4,121.75		3250		62,000	33,129,858,152
Delaware & Hudson	1,520.95		2840		75,000	12,005.064,448
D. L. & W.	2,507.56		3250		69,500	22,320,767,024
Erie	5,073.00		3250		73,000	46,269,448,664
Montour	76.95		2880		60,000	343,185,000
N. Y. C. Lines	14,802.14		3250		64,350	127,676,211,928
N. Y. C. & St. L.	2,634.38		3250		65,000	20,310,977,240
N. Y. N. H. & H.	4,521.88		3115		63,000	25,151,115,560
Pennsylvania	22,820.13		2980		76,000	207,977,006,376
Wabash	3,364.00	3250			69,500	27,488,670,976
		WESTERN GROUP				
C. St. P. M. & O.	2,374.56	2970			70,000	9,288,726,408
D. & R. G. W.	3,479.70	3250			70,000	10,846,575,584
Great Northern	10,126.57		3250		70,000	38,568,480,736
Kansas City Southern	1,327.56	3200			63,500	6,839,136,624
Missouri-Illinois	243.69	3250			49,000	384,197,696
M. K. T.	4,019.98	3250			60,000	19,600,458,928
Missouri Pacific	9,305.29	3250			69,000	49,984,437,464
Northern Pacific	9,062.23		3250		70,500	31,236,769,712
Southern Pacific	12,895.50	3250			69,600	72,735,863,784
St. Louis-Southwestern	983.30	3500			61,500	5,655,454,208
St. Louis - San Fran.	6,966.73	3000			65,000	27,374,549,976
Union Pacific	5,949.00	2980			60,000	50,130,293,752
Utah	86.24	2980			61,000	476,071,000
		SOUTHERN GROUP				
A. B. & C.	789.46		2880		51,750	1,756,719,200
Atlantic Coast Line	6,892.25		3115		63,000	25,594,508,488
Central of Georgia	2,569.56	3250			62,390	9,132,342,584
Georgia & Florida	489.77		2560		50,000	468,436,824
N. C. & St. L.	1,598.84		2880		63,000	7,719,420,960
Southern	9,004.43		3250		62.000	45,968,805,104
		POCAHONTAS GROUP				
Chesapeake & Ohio	4,298.28		3250		77,500	49,879,881,760
R.F. & P.	379.43		2980		70,000	4,033,728,112
		CANADIAN GROUP				
Canadian National	30,857.50	3250			65,000	-
Canadian Pacific	20,893.00	3000			63,500	-

REPORT OF COMMITTEE IX—GRADE CROSSINGS

J. G. BRENNAN, *Chairman;*
G. J. ADAMSON,
R. W. BARNES,
F. D. BATCHELLOR,
H. D. BLAKE,
F. J. BLICKENSDERFER,
T. E. BLISS,
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S. N. CROWE,
L. B. CURTISS,
A. R. DEWEES,
G. N. EDMONDSON,
H. L. ENGELHARDT,
H. W. FENNO,
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BERNARD BLUM, *Vice-Chairman;*
M. V. HOLMES,
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H. M. SHEPARD,
A. H. UTTER,
V. R. WALLING,
LEROY WYANT,
W. L. YOUNG,
A. M. ZABRISKIE,

Committee.

To the American Railway Engineering Association:

Your Committee on Grade Crossings submits the following report:

1. Revision of Manual (Appendix A).

(a) The illumination of highway crossbuck signs by means of the use of reflecting buttons. Committee reports progress, and recommends that the subject be continued.

(b) The proper location of the whistling post, in view of the modern tendency of traffic crossing highway crossings. Recommended that the present practice be continued and the recommendation received as information.

(c) The proper lighting of the base of signals where located in the center of the highway. Recommended that the conclusion be received as information, and the subject assigned for further investigaton during the coming year.

(d) Illumination of Advance Warning Sign for railroad crossings. That the recommendation be approved and the Manual revised accordingly.

(e) Revision of wording in A.R.E.A. Bulletin 337 of July, 1931. Committee recommends that change be made.

2. Comparative merits of various types of grade crossing protection (Appendix B) Recommended that the report be received as information.

3. Economic aspects of grade crossing protection in lieu of grade separation (Appendix C). Recommended that the subject be continued.

4. Methods and forms for classifying highway crossings of railways and forms for recording and reporting highway and railway traffic over highway grade crossings (Appendix D). Recommended that the report be received as information and the recommendation approved for publication in the Manual.

5. Methods and principles for determining the order in which protection, elimination and separation of grades of highway grade crossings should be undertaken (Appendix E). Recommended that the report be received as information.

6. Study laws, regulations and practices governing dimensions and clearances affecting construction, protection, elimination and separation of grades of highway grade crossings (Appendix F.) Committee reports progress and recommends that the subject be continued.

7. Study laws and practices for determining division of cost of highway grade crossing separations (Appendix G). Committee reports progress and recommends that the subject be continued.

Respectfully submitted,

THE COMMITTEE ON GRADE CROSSINGS,

J. G. BRENNAN, *Chairman*

Bulletin 343, January, 1932.

Appendix A

(1) REVISION OF MANUAL

P. M. Gault, Chairman, Sub-Committee; H. D. Blake, Bernard Blum, H. E. Brink, M. V. Holmes, G. P. Palmer, W. C. Pinschmidt, Frank Ringer, Leroy Wyant.

(a) The illumination of highway crossbuck signs by means of the use of reflecting buttons.

This assignment has been subject to study and consideration by the Committee during the year. The Committee recommends that the subject be continued.

(b) The proper location of the whistling post in view of the modern tendency of traffic crossing highway crossings.

Recommendation

The Committee recommends that the present practice of locating whistle post one-quarter (¼) mile from the grade crossing be continued. In special cases, where local conditions require, distance of whistle post from crossing may be varied, if not in conflict with law. To be received as information.

(c) The proper lighting of the base of signals where located in the center of the highway.

Conclusion

The Committee is of the opinion that the proper lighting of base of signals where located in center of highway is adequately taken care of by present A.R.E.A. standards. To be received as information, and the subject assigned for further investigation during the coming year.

(d) The illumination of advance warning sign for railroad crossings.

Recommendation

The Committee recommends that the present standard advance warning sign as shown in Fig. 6, page 664 of the Manual, 1929, be revised to provide that the letters "R R" and the Cross "(+)" be illuminated by means of reflecting buttons, as illustrated in the accompanying sketch (Exhibit A).

(e) Revision of wording in A.R.E.A. Bulletin 337 of July, 1931.

The Committee recommends that the first word of the second line in item No. 4, page 64, "Highway Crossing Signs and Signals," of A.R.E.A. Revisions and Additions to the Manual, Bulletin 337 of July, 1931, be changed from "may" to read "should".

Appendix B

(2) COMPARATIVE MERITS OF VARIOUS TYPES OF GRADE CROSSING PROTECTION

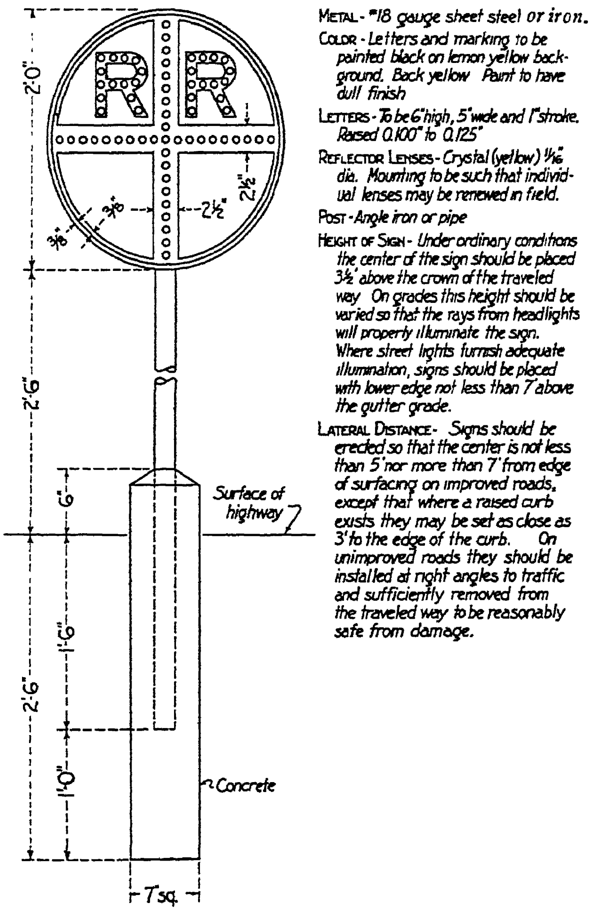
W. C. Pinschmidt, Chairman, Sub-Committee; Bernard Blum, H. D. Blake, F. J. Blickensderfer, G. N. Edmondson, H. L. Engelhardt, P. M. Gault, J. P. Hallihan, Maro Johnson, L. J. Riegler, H. M. Shepard, V. R. Walling, Leroy Wyant.

Relatively few new protective devices have come to the attention of the Committee during the past year.

Exhibit A

ADVANCE WARNING SIGN

Scale: 1" = 6" October 9, 1931.



Following is a list of the various types of grade crossing protection given consideration during the year. They are briefly described from the claims of the manufacturers.

1. **New Life Protector—National Safety Appliance Corporation, Nashville, Tenn.**—This is a barrier, which is depressed below the highway surface until a train approaches the crossing. It first rises vertically, in a horizontal plane, to a height of 3 inches, to allow traffic time to clear the crossing, and then rises to its full height of 15 inches. The words "Stop—Stop" are displayed on the barrier when it is in the raised position. The barrier is operated automatically by trains, either hydraulically or electrically.

A

2. **Wallace and Tiernan "R.R." Flasher, Type FA-38,—Wallace and Tiernan Products, Inc., Belleville, N. J.**—This is an advance warning sign equipped with an amber light which flashes constantly at the rate of 45 flashes per minute. It is operated by dry batteries and is equipped with a lamp changing device.

The battery consists of dry cells, three series, three parallel, giving 4½ volts. The minimum length of service with one set of lamps and batteries is claimed to be six months.

3. **Automatic Safety Signal Gate—Automatic Safety Signal Gate Company, Louisville, Ky.**—This is a hydraulic automatic crossing gate, electrically controlled, and can be operated on either an open or closed circuit. The gate can also be operated manually or by a suitable combination of automatic and manual operation. The arms rotate horizontally, if struck, and the hydraulic pressure is so regulated as to eliminate the possibility of damaging a vehicle caught under a descending gate. The gates are equipped with lamps.

A four-gate installation has been in operation for over one year, on a double-track railway.

4. **Buda Automatic Crossing Gate, Model 51—The Buda Company, Harvey, Ill.**—This is an electric automatic gate, with a counterbalanced arm, and with anti-friction bearings in all moving parts. It operates on a storage battery, which is floated on a one ampere charger. The arms rotate horizontally if struck, and are so adjusted that if a descending or rising gate is obstructed, the motor will stop until the obstruction is removed.

An installation of two gates on double main line steam railway, where 95 train movements occur daily and where the gates are equipped with 2 ruby marker lights per arm, 1 arm illuminator beam light per arm, 1 bell per gate, circuit relays and 2 motors, operates on 17 ampere hours daily.

5. **Proper Crossing Guard—W. H. Proper, Inventor.**—This is a barrier, consisting of heavy reinforced ribbed sheet steel plate, hinged at the roadway level, on the side nearest the track. In the normal position, the plate is level with the roadway, but when a train enters the circuit the plate rises to a sloping position and a light appears from under the plate, displaying a warning indication at the surface of the highway.

The device is equipped with double synchronizing shock absorbers to prevent injury to an automobile striking it at 25 miles per hour.

Recommendation

It is recommended that the report be received as information.

Appendix C

(3) ECONOMIC ASPECTS OF GRADE CROSSING PROTECTION IN LIEU OF GRADE SEPARATION

G. P. Palmer, Chairman, Sub-Committee; A. R. Dewees, W. M. Jaekle, F. D. Kinnie, A. E. Korsell, E. R. Lewis, Frank Ringer, A. H. Utter, W. L. Young.

The Committee has been engaged in assembling additional cost data covering the annual cost of various types of highway crossing paving, including fixed signs, and the annual cost of various types of crossing protection. Questionnaire was sent to ten representative railways but replies received only from four of them. Information available is incomplete and does not warrant a conclusion.

Recommendation

It is recommended that the subject be continued for further investigation and study during the coming year.

Appendix D

(4) METHODS AND FORMS FOR CLASSIFYING HIGHWAY CROSSINGS OF RAILWAYS AND FORMS FOR RECORDING AND REPORTING HIGHWAY AND RAILWAY TRAFFIC OVER HIGHWAY GRADE CROSSINGS

H. E. Brink, Chairman, Sub-Committee; H. D. Blake, E. R. Cott, S. N. Crowe, L. B. Curtiss, G. N. Edmondson, J. P. Hallihan, M. V. Holmes, H. A. Hampton, R. B. Kittredge, W. B. Knight, E. R. Lewis, H. M. Shepard, A. H. Utter, V. R. Walling.

FORM FOR RECORDING HIGHWAY GRADE CROSSINGS
NORTH AND SOUTH RAILWAY

Date....................

MUNICIPALITY ....COUNTY ....STATE ....
DIVISION ....BRANCH ....

Information should be obtained by field inspection and from records. It should be compiled on ground in tabular form which should be filled out, dated and certified as correct by the Engineer making the inspection. Information shall be compiled for all grade crossings of highways, local roads and streets by operating divisions serially in the order of mileposts.

1. Milepost number ....(If new—date installed) ....
2.* Class of highway, local road or street as follows: ....
3. U. S. number of highway or street ....
4. State number of highway or street ....
5. Name of highway, road or street ....
6. Number of street car tracks ....
7. Number of main tracks crossed ....
8. Number of side and/or spur tracks crossed ....
9. Tracks of other Railroads ....
10. Approximate angle of crossing ....
11. Character of highway alinement for 1000 feet each side of crossing ....
....
12.* Kind of surface of highway, road or street, approaching the crossing: ....
13. Width of surface of highway, road or street, within 500 feet each side of crossing...
14.* Kind of surface of crossing ....
15. Length of surface of crossing, measured along center line of railroad ....
16.* Visibility ....
17.* Approach highway grades (state whether ascending or descending) ....
18. Maximum speed of passenger trains (m.p.h.) ....
19. Maximum speed of freight trains (m.p.h.) ....
20. Number of passenger trains per day (24 hours) ....
    (average for one month) ....
21. Number of freight trains per day (24 hours) ....
    (average for one month) ....
22. Number of switching movements per day (24 hours) ....
    (average for one month) ....
23. Highway traffic per day (24 hours). Show number from representative traffic count ....
24.* Kind of protection ....
25.* Is elimination of grade crossing feasible ....
26. What percentage of highway traffic can be diverted by relocation ....
27. Total accidents at crossing for a period of past five years ....
28. File Reference ....

Note—If this grade crossing is eliminated enter following data.
A.F.E. No. ....Date ....Method ....

* For explanatory notes, see back of sheet.

EXPLANATORY NOTES

(2) *Abbreviation* *Class*

F.A.P. .... Federal Aid—Primary
F.A.S. .... Federal Aid—Secondary
O.R. .... Other Roads—State or County
L.R. .... Local Road
Street .... Street within limits of incorporated city, not maintained by state highway commission.

(12) (a) Concrete, brick, etc.
(b) Bituminous macadam or bituminous concrete.
(c) Waterbound macadam, gravel, etc.
(d) Earth.

(14) (a) Metal or metal and concrete.
(b) Stone, concrete or brick.
(c) Bituminous.
(d) Crushed stone, gravel or slag.
(e) Plank (Wood).
(f) Plank (Concrete, bituminous, etc.).
(g) Patented materials.
(h) Earth.

(16) (a) "Good"—Train or locomotive visible for at least one thousand feet each way along track from approaching vehicle within a distance of two hundred feet either way from crossing.
(b) "Fair"—Train or locomotive visible for at least one thousand feet each way along track from approaching vehicle within a distance of one hundred feet either way from crossing.
(c) "Restricted"—Other conditions.

(17) (a) "Easy"—Approximately level for 10 to 20 feet and thence not over 5 per cent.
(b) "Medium"—Approximately level for 10 to 20 feet and thence 5 per cent to 8 per cent.
(c) "Steep"—Approximately level for 10 to 20 feet and thence over 8 per cent.

(24) (a) Gates, with or without other protection, operated 24 hours per day.
(b) Gates, with or without other protection, operated less than 24 hours per day.
(c) Watchmen, alone or with protection other than gates, on duty 24 hours per day.
(d) Watchmen, alone or with protection other than gates, on duty less than 24 hours per day.
(e) Both audible and visible signals, without other protection.
(f) Audible signals only.
(g) Visible signals only.
(h) Special fixed signs or barriers, with or without standard fixed signs.
(i) Standard fixed signs only.
(j) Approach signs.
(k) Stop and flag.
(l) Otherwise unprotected.

(25) (a) By relocation of highway—considering topography, property values and adjacent improvements at reasonable cost.
(b) By separation of grade—considering topography, drainage, adjacent improvements and possible change in grade of highway or railroad at reasonable cost.
(c) By vacation or closing and diversion of traffic to other crossing or crossings, considering the character and density of highway traffic and extent of inconvenience thereto.

FORM NO. ______

NORTH AND SOUTH RAILWAY

RECORD OF TRAFFIC AND DELAYS AT GRADE CROSSINGS, RAILWAY WITH HIGHWAY

RECORDER'S SHEET

PROTECTION ______ WEATHER ______
NAME OF HIGHWAY ______ MILE POST NUMBER ______
LOCATION ______ TOWN OR CITY ______ STATE ______
RECORDER ______ DAY ______ DATE ______

	Highway Traffic							Highway Traffic Delays		Railway Traffic								
		Vehicles								Passenger		Freight		Switch Movements				
Hour	Pedestrian	Automobiles	Busses	Trucks	Total	Street Cars	Miscellaneous	Duration of Delay	Delay in minutes from 1st car stopped to last car moving ahead	North or East	South or West	North or East	South or West	North or East	South or West	Total	Delays	Remarks Note any changes in weather or protection during day
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Total																		

SIZE OF FORMS:- EACH CARRIER SHOULD ADOPT A STANDARD SIZE AND ALL FORMS SHOULD BE THAT STANDARD SIZE OR MULTIPLES THEREOF (SEE 1929 MANUAL, P 743)

USE LINE FOR EACH HOUR AND FOR EACH RAILWAY MOVE

Form No. ______

RECORD OF TRAFFIC AND DELAYS AT GRADE CROSSINGS, RAILWAY WITH HIGHWAY

NORTH AND SOUTH RAILWAY

SUMMARY SHEET

Name of Highway ______ Mile Post Number ______

Location ______ Town or City ______ State ______

Date	Highway Traffic							Highway Traffic Delays				Railway Traffic								Remarks
	Pedestrians	Vehicles				Street Cars	Miscellaneous	(a) Total Number of Vehicles Delayed	(b) Total of Average Delay in Minutes	(c) Number of Delays	Total Car Hour Delays = $\frac{ab}{60c}$	Passenger		Freight		Switch Movements		Total	Delays	
		Auto Mobiles	Busses	Trucks	Total							North or East	South or West	North or East	South or West	North or East	South or West			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)

SIZE OF FORMS:- EACH CARRIER SHOULD ADOPT A STANDARD SIZE AND ALL FORMS SHOULD BE THAT STANDARD SIZE OR MULTIPLES THEREOF (SEE 1929 MANUAL, P 743)

Recommendation

It is recommended that the form for recording highway grade crossings be printed in the Manual, and that the summary form, previously printed in Proceedings for 1931, Vol. 32, page 87, be omitted, but that reference be made to it as information.

It is further recommended that the forms for recording traffic and delays at grade crossings, recorder's sheet and summary sheet, be printed in the Manual.

Appendix E

(5) METHODS AND PRINCIPLES FOR DETERMINING THE ORDER IN WHICH PROTECTION, ELIMINATION, AND SEPARATION OF GRADES AT HIGHWAY GRADE CROSSINGS SHOULD BE UNDERTAKEN

Bernard Blum, Chairman, Sub-Committee; G. J. Adamson. H. D. Blake, T. E. Bliss, C. W. Charleson, A. R. Dewees, H. W. Fenno, R. C. Gowdy, F. S. Hales, A. G. Holt, R. B. Kittredge, L. J. Riegler, A. M. Zabriskie.

1. This assignment is understood to mean the ascertainment of principles and the setting up of methods to be used in measuring the relative importance, necessity, and expediency of projects at certain grade crossings, regardless whether the solution is protection of the crossings or their elimination by grade separation or by some other methods. The relative expediency as between protection and some form of elimination incidentally would be developed.

2. The word "Protection" in the heading is considered as referring to wigwags, flashlights, or other types as may be recommended practice, and "Elimination" as abandonment through relocation or other means.

3. It is assumed that the assignment covers the order of importance from the viewpoint of the railways rather than from that of States or municipalities. The public's choice or demand is largely governed by highway projects which for the moment are in process of construction. It is not unusual for a Highway Department to request separation of grades at crossings of tracks of secondary importance to accommodate a new highway, while crossings of more important tracks remain at grade.

4. It does not necessarily follow that the desired order of grade crossing improvements from the standpoint of the railways and the public authorities is the same. It would seem well nigh impossible for a single railway company to determine the relative importance of grade crossings in their relation to highway projects as a whole. The order of importance logically appears to be governed by the hazards and the potential economies. The latter may be subdivided into benefits to the railway and to the public using the highway.

5. Formulae have been developed for classifying grade crossings for determining the priority of separation by appraising the hazards as determined by the number of vehicles and trains passing over each one and as influenced by sight distances, angles and grades of approach, speed of trains, etc. It indeed would be difficult for two individuals to agree as to potential dangers at grade crossings and the weights to be assigned to the various factors. Some of the factors involving hazards are not measurable so that logical treatment is not possible. Speed and density of traffic on the highway and railway, of course, must be considered and given due weight, but mathematical formulae in our opinion do not solve the problem.

6. It well may be conceded that the present method of handling is not conducive to the best interests of either the railways or the public even though the records of crossing accidents in relation to registered automobiles show reductions each year While a method could be devised for equating the traffic density over crossings, mere preponderence of traffic as determined by numbers of automobiles and trains solely does not measure the importance of crossings with respect to improvement.

7. Results obtained from a survey of crossings made today might not reflect conditions very far in the future for the reason that traffic flows rapidly change as new highways are built or industrial conditions change. Such changes frequently multiply the highway traffic on a road previously considered unimportant. The rapid increase

in automobile traffic is partly due to highway construction which invites travel. Consequently in determining the order of grade crossing improvements one of the first steps is to study the development plans of the State Highway Departments and City Planning Boards with the view of shaping the railway's plans to harmonize with a well-conceived general scheme. Such a plan as serves the public best, in general will be advantageous to the railways.

8. It would seem in the days before the present automobile era that slow-moving vehicles would have required more crossings than are needed at the present time when a slightly longer route is not serious, but in fact the total number of grade crossings has increased each year notwithstanding the considerable number of separations and eliminations of existing grade crossings. This may in part be due to the erroneous idea held by local interests that a crossing necessarily is an asset. On the contrary, it frequently can be shown that the interests of all are better served with fewer crossings sufficient for the traffic.

9. Public considerations demanding improvements will bring to the front the benefits to the public and indicate the justification for it to assume a proper share of the cost. A well-conceived development layout of an industrial area or a general road scheme necessarily will involve a definite plan of main arteries, secondary road crossings and possibly lanes merely for industry requirements which will render comparatively easy the task of determining the order in which the plan should be worked out and also the necessity as between protection and separation or elimination.

10. However desirable it would be for a railway to have a list in numerical order measuring the relative importance in which improvements at all its highway grade crossings should be undertaken, the many factors which are not susceptible of exact solution would make the result indeterminate. Nevertheless a thorough investigation of community and trunk road development as outlined should be made before construction is begun.

11. The following article by John P. Hallihan, Chief Engineer, Rapid Transit Commission, Detroit, is of such interest in connection with this subject that it is incorporated as a part of this report. It indicates that practical results can be obtained when the subject is properly approached.

Recommendation

The Committee recommends that the report be received as information.

THE ADVANTAGE OF GROUP PARTICIPATION OF RAILWAYS IN CONSIDERATION OF GRADE SEPARATION PROBLEMS IN CITIES

By John P. Hallihan, Chief Engineer, Rapid Transit Commission, Detroit

The question of elimination of grade crossings of railways in cities and contiguous areas has been increasing in importance with the increase in ownership and use of automobiles until it now ranks as one of the greatest problems that the railroads have to consider.

It is much more serious and difficult of solution in cities than in the open country.

The increase in volume of traffic on the roads in the open country creates a situation altogether different from any that could have been conceived twenty-five years ago.

At that time there was less than one automobile per mile of improved road whereas today there are more than forty cars per mile of improved road and the attempts of government agencies to provide adequate road space, liberally financed as they are through the gasoline tax, fall far behind the demand as indicated by the increase in motor vehicle registration.

In the neighborhood of cities, vehicular traffic has a compounding effect. Analysis of the two-way traffic on five principal trunk line highways entering Detroit for a 24-hour period shows the composite total to be as follows:

At the 40-mile circle	31,400
30-mile circle	40,400
20-mile circle	61,200
15-mile circle	77,200
10-mile circle	103,400
5-mile circle	168,000

Under these conditions, great pressure has been brought to bear on cities to widen existing thoroughfares and to create new ones, too, so that more room would be available for the use of individual automobiles.

In turn, the city authorities have urged the railways to increase their appropriations for elimination of grade crossings. The railways have not been particularly sympathetic to this appeal because it was apparent that under the current practice in cities of permitting every road or street of purely local interest to cross the railway tracks, that for every crossing eliminated by separation of grades several more were being created.

In the nation generally, as brought out in 1927 before the Western Society of Engineers by Robert H. Ford, Assistant Chief Engineer of the Rock Island Lines, the control of highways and grade crossings is in the hands of over 150,000 unrelated bodies more or less independent of each other and political in composition, a situation quite in contrast with the control of the railways by the Interstate Commerce Commission.

It became necessary, in Detroit, in 1925, to analyze the grade crossing question with some care, because it was directly related to the Master Plan of thoroughfares designed by the Rapid Transit Commission, as a foundation for future transit facilities.

The analysis made it clear that the practice of piecemeal separation under pressure by local interests was productive of impermanence and waste to the city, the railways and the industries and that great economies and better results were possible if the railways and city authorities could be brought together in the design of a comprehensive plan in line with the projected revision of the street system to meet the needs of traffic and city transit.

It was demonstrated, in an article published by the writer in the *Railway Age* of June 26, 1926, that even under crystallized conditions in the heart of the city, a much better job could be done for the same money by reducing the number of separations and adjusting the street system to delimit and conserve the industrial territory while providing ease of access to thoroughfares of adequate traffic capacity.

In territory of less intensive development industrially where preparedness measures could be taken in advance of need, it appeared probable that the saving over former practice might easily reach a half million dollars per mile.

Continuance of discussion on this subject with the railways and the more important industries finally resulted in the constitution of a Committee on Grade Separation by the Milwaukee Junction Manufacturers Association, representing 175 industries operating in the eastern half of the city, employing 200,000 workers and turning out annually more than a billion dollars in value of manufactured products.

Later this association was joined by the Belt Line and Terminal groups so that finally it aggregated 415 industrial plants.

The committee had no official standing.

It invited into its deliberations all the railways and public service bodies interested in Detroit and the contained municipalities of Highland Park and Hamtramck. On November 4, 1929, after a general agreement on purpose and scope of work, it created an

Engineers Committee composed of two representatives each of the cities, the railways and the industries, to carry on the detailed investigations.

In its first general report, the Engineers Committee presented its conception of its job, which was briefly as follows:

> To reduce the number of grade separations to the lowest number consistent with the service of the general traffic, limiting the crossings of the railways to the major and secondary thoroughfares. Any others, except as they might become necessary for a fire department route or a street-car route, would be regarded, the committee stated, as superfluous and extravagant.
>
> Intermediate streets would not be maintained as grade crossings, but by the creation of traffic headers at a suitable distance from and as nearly as may be paralleling the railways, there would be afforded easy access to the main thoroughfare crossings. The roadways would be of ample width for requirements of volume traffic.
>
> The character of structure would be determined in occupied territory by the industrial plant requirements and by the effect of changes in track profile on the service tracks, on operations of existing industries, and on the parallel and cross-street system. Other advantages being equal, comparative cost would govern.

On this basis the committee announced that it proposed to reduce the number of permanent railway crossings in the eastern half of the city from a possible 199 to 73, with the aid of a local revision of the street system. Three subsequent reports have dealt with the detail plans on individual roads. All have been unanimously approved by the Common Council of the City of Detroit. A fourth and final report is in preparation.

The work of the committee is regarded as an important forward step in regional planning.

It is the first time in any city, so far as known, that all the various public and private interests concerned in the problem of elimination of grade crossings have been brought together to find the best solution from a non-partisan, common-sense, economic viewpoint.

The result has proven the value of the participation of the railways in civic matters. Controversial questions that had long been the subject of discussion between railway and railway, and city and railway, were speedily and amicably settled with the help of industry, the third and most important party in interest, highly qualified to act as a balancing factor.

Incidentally, the committee declined to consider the question of division of costs between the city and the railways, but three of its members invited by the Common Council to sit on a special city committee to determine that question with an individual road, defined the elements that should enter into the accounting, whatever division of the total might be agreed upon between the parties interested in the light of other conditions.

There is no effort to accelerate the construction program, though it is recommended that preference be given the major thoroughfares serving industrial traffic.

The net result of the work of the committee is to eliminate a condition of uncertainty, indecision, impermanence and waste. In lieu of this it offers a definite workable plan in line with modern requirements, to be accomplished as needs dictate and circumstances permit. Perhaps the most important immediate benefit is derived by the cities and the railways who are now in position to assure new industries seeking locations, of the exact position of the track profile, of projected thoroughfare openings, of probable land takings, and of the elimination of unwarranted local street intrusions into industrial territory.

REPORT OF COMMITTEE X—SIGNALS AND INTERLOCKING

P. M. Gault, *Chairman;*
C. H. Tillett, *Vice-Chairman;*
F. H. Bagley,
G. H. Dryden,
W. J. Eck,
W. H. Elliott,
*G. E. Ellis,
J. V. Hanna,
C. R. Hodgdon,
C. A. Mitchell,
J. C. Mock,
R. D. Moore,
H. G. Morgan,
H. H. Orr,
J. A. Peabody,
F. W. Pfleging,
W. M. Post,
A. H. Rudd,
F. S. Schwinn,
T. S. Stevens,
E. G. Stradling,
W. M. Vandersluis,
F. B. Wiegand,
Leroy Wyant,

Committee.

* Died, December 16, 1931.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) Developments of automatic train control, collaborating with Train Control Committee, A.R.A. (Appendix B).

(3) Developments of automatic highway crossing protection, collaborating with Committee IX—Grade Crossings. A designated member of your Committee has collaborated as requested.

(4) Increased efficiency secured in railway operation by signal indication in lieu of train orders and timetable superiorities, collaborating with Committee XXI—Economics of Railway Operation (Appendix C).

(5) Synopsis of the principal current activities of the Signal Section, A.R.A., supplemented with list and references by number of adopted specifications, design and principles of signaling practice (Appendix D).

(6) Furnish the Special Committee on Clearances the information required by it pertaining to signals and interlocking. A designated member of your Committee has collaborated as requested.

Action Recommended

(1) That Appendix A be approved.
(2) That Appendix B be received as information.
(4) That Appendix C be received as information.
(5) That Appendix D be received as information.

Respectfully submitted,

The Committee on Signals and Interlocking,
P. M. Gault, *Chairman.*

Bulletin 343, January, 1932.

Appendix A

(1) REVISION OF MANUAL

W. M. Vandersluis, Chairman, Sub-Committee; J. V. Hanna, W. M. Post, C. H. Tillett.

The 1929 Manual of the A.R.E.A. contains, on pages 667 to 699 inclusive, a complete index of the Manual of the Signal Section, A.R.A., for the convenience of the members. This is preceded by an explanatory note.

The subsequent Bulletins of the A.R.E.A. referring to the Manual contain no references to revisions of the Signal Section Manual, although several are made each year.

With a view to bringing the A.R.E.A. Manual up to date, authority is requested to print in the next supplement to the Manual the index to the Signal Section Manual.

Appendix B

(2) DEVELOPMENTS OF AUTOMATIC TRAIN CONTROL

G. E. Ellis, Chairman, Sub-Committee; W. J. Eck, W. H. Elliott, F. W. Pfleging.

There has been no material change in the mileage and number of locomotives equipped during the last year.

The Bureau of Safety has completed its inspections, and reports covering the various installations.

On the question of interchangeability, the Committee on Automatic Train Control, A.R.A., is continuing its studies, but owing to the present conditions only a limited amount of road work has been done. Locomotives have been equipped for operation over the second order installation of the New York, New Haven & Hartford Railroad over the Union Continuous Stop—Code System, and the Boston & Maine Continuous Stop. The operation of these locomotives will be noted in connection with the Committee's studies of interchangeability.

The Great Northern Railway filed a petition with the I.C.C. for relief from maintaining and operating its train control installation. The railway was granted a hearing and testimony taken. Decision is pending at the time this report is being written.

Appendix C

(4) INCREASED EFFICIENCY SECURED IN RAILWAY OPERATION BY SIGNAL INDICATIONS IN LIEU OF TRAIN ORDERS AND TIMETABLE SUPERIORITIES

W. M. Post, Chairman, Sub-Committee; G. H. Dryden, W. J. Eck, P. M. Gault. C. A. Mitchell, F. W. Pfleging, W. M. Vandersluis.

Committee X has presented two reports on this subject; the first at the 1929 annual meeting and the second at the 1930 annual meeting.*

This report relates to centralized traffic control (CTC) which is an improved system for railway operation by signal indication.

In this new system, introduced in 1927, the signals and switches of the district are operated and controlled from a central point by a CTC operator solely by the use of electrically controlled signaling devices. The CTC operator directs the movements of trains by operating the signals whose indications authorize the movement.

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* 1929 Report, Proceedings, Vol. 30, pp. 524–542; Discussion, pp. 1444–1445.
1930 Report, Proceedings, Vol. 31, pp. 1040–1058; Discussion, pp. 1729–1730.

By direct operation of the switches as well as the signals, the operator also sets up the routes as required. Through the elimination of the task of issuing written train orders, the CTC operator can concentrate all of his efforts on keeping trains moving with minimum delay and so assure an intensive utilization of track facilities and equipment.

This new system made it economically possible to greatly extend the territory controlled from a single station.

TRAIN OPERATION BY SIGNAL INDICATION PROGRESS

	Installations	*Miles of Road*
Progress from 1882 to 1929**	167	1648.1
Less CTC installations 1927–1929	15	366.8
Total exclusive of CTC installations	152	1281 3
CTC installations 1927 to November, 1931	57	979.9
Total all installations 1882 to November, 1931	209	2261.2
CTC installations—per cent of totals	27	43

It will be noted that CTC has made rapid progress as in the short space of four years CTC represents 43 per cent of the total miles of road equipped for train operation by signal indication.

The CTC installations included in the above tabulation are those that provide for train movements under the authority of signal indications on single-track lines and on multiple-track lines in both the normal and reverse directions. The listing of the CTC installations was made in this way to be in accord with the terms of the assignment.

Operation under Centralized Traffic Control

Train operation by signal indication is extensively used for train movements in the normal direction on multiple-track lines. The CTC system made it economically possible to direct train movements on single-track and on multiple-track lines in either normal or reverse direction under the authority of signal indications thus eliminating the use of train orders except for special instructions. Through this elimination of train orders for directing train movements, the delays inherent in their use are avoided.

A CTC installation may be said to be an interlocking plant extended over many miles of territory. Train movements under CTC are made exactly as they are made through an interlocking as the switches and signals are controlled from a central point by a CTC machine with the same facility and with all the protection provided by an interlocking machine.

"OS"ing Trains (Reporting Trains to Train Dispatcher)

In a CTC installation the information as to train movements is conveyed to the CTC operator by the illuminated track diagram or its equivalent. In addition the train graph records the train movements supplementing the hand written train sheets.

The automatic "OS", a distinctive feature of the CTC system, sends in the "OS" from each control point. On the installations in use the average distance between control points is 1½ miles. This enables the CTC operator to keep more closely in touch with train movements than is possible where the non-automatic "OS"es are sent in from telegraph stations.

** See Proceedings 1930, pp. 1040–1058.

CENTRALIZED TRAFFIC CONTROL

The data on centralized traffic control is taken from: (a) Information furnished by the railroads; (b) Proceedings of the A.R.A. Signal Section; (c) Railway Age; and (d) Railway Signaling. This data includes four distinct types of installations.

Types of CTC Installations

The types of CTC installations in use as of November, 1931, may be summed up as follows:

(a) CTC installations on both single and double track for the relief of traffic congestion through short or bottle-neck sections, gauntlets or tunnels.

(b) CTC installations on 332 miles of single track, the sections ranging from two to fifty-five miles in length for the purpose of postponing double-tracking, particularly in locations where the construction costs make double-tracking economically impossible.

(c) CTC installations on over 400 miles of multiple-track lines for either-direction operation on one or more of the tracks.

(d) CTC installations on multiple-track lines for the consolidation of interlocking plants making one CTC station control two or more interlocking layouts. This type of installation fully meets the difficult requirements of a busy terminal railroad with numerous junction points.

CENTRALIZED TRAFFIC CONTROL INSTALLATIONS IN USE AS OF NOVEMBER, 1931

Railroads	*No. of installations*	*Miles of Road*					*Power Switches*	*Signals*	*"OS" Points*
		Single Track	*Double Track*	*Three Track*	*Four Track*	*Total Miles*			
AT&SF	3	27.1	19.7			46.8	28	121	27
B&O	3	101.3	1.6			102.9	65	249	62
B&G	1	16.0				16.0	2	49	15
B&M	11	4.8	123.8	30.4		159.0	215	592	143
CP	1	9.0				9.0	2	18	4
CRR of NJ	1				4.4	4.4	6	9	2
C&NW	2	8.5				8.5	5	25	9
CB&Q	7	55.0	15.5			70.5	70	170	50
CGW	1	1.6				1.6	2	6	2
CMStP&P / CRI & P	1		37.7			37.7	11	59	5
CRI&P	1	10.3	10.4			20.7	4	16	4
D&H	1	6.6	5.7			12.3	6	47	22
D&RGW	2	36.5	2.5			39.0	14	69	26
Erie	1		17.3			17.3	4	4	6
IC	2	4.2	15.0			19.2	11	66	10
LV	1	11.2				11.2	2	8	2
MP	4	54.5	44.5			99.0	49	243	70
NYC	1	36.9	3.3			40.2	32	102	32
N&W	1	8.5				8.5	1	9	2
Pad. & Ill.	1	15.0				15.0	13	30	7
Penna.	1	30.0				30.0	12	32	11
P&PU	1		6.4	0.7		7.1	20	37	17
PM	1	20.0				20.0	8	34	8
SP	1	37.1	2.6			39.7	23	98	24
T&NO (SP)	2	23.0				23.0	10	59	11
T&P	4	4.2	80.1			84.3	32	197	24
Wabash	1	37.0				37.0	13	65	14
Totals	57	558.3	386.1	31.1	4.4	979.9	660	2,414	609

Summary of Table

Centralized traffic control is in use on twenty-seven railroads (as of November, 1931) with a total of fifty-seven installations.

		Miles of Road	Miles of Track
Installations:	Single-track	558.3	558.3
	Double-track	386.1	772.2
	Three-track	31.1	93.3
	Four-track	4.4	17.6
	Totals	979.9	1441.4
CTC Operated Units:	Power switches	660	
	Signals	2414	
	"OS" points	609	

Train Miles Per Year Through the Fifty-Seven CTC Installations

Freight train miles	6,772,173
Passenger train miles	4,599,657
Total train miles per year	11,371,830

Total Cost of the CTC Installations

The I.C.C. Bureau of Safety Annual Reports for 1928, 1929 and 1930 show a total cost for CTC of $2,569,168 for a total of 686.4 miles of road. This gives an average cost per mile of road of $3,743.

At this average, the fifty-seven CTC installations covering 979.9 miles of road show a total cost of $3,667,766.

Total Net Saving of the CTC Installations Per Year

Due to the intensive use of track facilities, locomotives and cars under centralized traffic control, transportation costs show a substantial saving.

The principal items included in the saving are as follows:

(a) Freight train service out-of-pocket costs. The saving in these items reduces the costs per train mile and per 1000 gross ton miles.

(b) Signal stations replaced by CTC represent a large part of the saving in transportation costs. The 106 stations taken out of service included train order, block and interlocking stations. At a saving of $5,000 per station per year, there is a gross saving per year of $530,000.

(c) On multiple-track lines, an intensive use of track facilities is provided through either-direction operation on one or more of the tracks. In congested districts, this method of operation shows a substantial saving.

Figures are not available for the saving made by each of the installations. However, from the results of many economic studies, a net saving, after all charges, of 20 per cent of the installation cost may be regarded as a conservative figure. On this basis, the total net saving per year, after deducting maintenance, operation and interest on the investment, is $735,800.

Potential Saving

A potential saving may be of such a character that the amount of the saving can be definitely fixed; for example, a saving due to the postponement of the double-tracking

of single-track lines. The construction costs of the second track and the annual charges for maintenance, taxes and interest can be easily determined.

Thirteen CTC installations with a total of 332 miles were made to postpone double-tracking. The cost of the double-tracking, based largely on railroad estimates, amounts to $18,888,500. The annual charges may be placed at $1,908,750. These figures do not include installations where it is fairly evident that the traffic would not warrant the heavy cost of double-tracking.

The case for centralized traffic control may be summed up by quoting the following from a General Manager of a single-track line operating twenty-five freight trains a day (5,400 ton trains).

> "We are equipped with automatic signals and Centralized Traffic Control, whereby trains are operated by the indication of signals, so can appreciate all the good things these do for the railways.
>
> "We haven't issued a train order of any kind or description since December 18, 1929, except last month when we moved our dispatcher's office from one building to another, when it was necessary to put out one written order.
>
> "Our train and enginemen are enthusiastic about the Traffic Control.
>
> "In my opinion, moving trains by the indication of signals is the biggest improvement in train operation since the automatic air brake was adopted."

Appendix D

(5) SYNOPSIS OF THE PRINCIPAL CURRENT ACTIVITIES OF THE SIGNAL SECTION, A.R.A. SUPPLEMENTED WITH LIST AND REFERENCES BY NUMBER OF ADOPTED SPECIFICATIONS, DESIGN AND PRINCIPLES OF SIGNALING PRACTICE

H. H. Orr, Chairman, Sub-Committee; E. G. Stradling, L. Wyant.

CURRENT ACTIVITIES OF THE SIGNAL SECTION, A.R.A., SINCE MARCH, 1931

Investigations and reports cover the following:

1. Centralized traffic control system requisites.
2. Automatic block signal system requisites.
3. Interlocking system requisites.
4. Development of automatic train control and cab signals.
5. Method of comparing operating results before and after an improvement in signaling facilities.
6. Highway crossing protection:
   (a) Revision of requisites to harmonize with A.R.A. recommended practice.
   (b) Federal and state activities.
7. Standardization of colors for lenses and roundels.
8. Instructions pertaining to relays, batteries and time releases.
9. Investigation of condensation and frost on signal apparatus.
10. Forms for signal and train control records.

Specifications Revised

	Old No.	New No.
Double-braided, weatherproof, thirty per cent conductivity, copper covered steel line wire	7118	7131
Electric motor switch operating mechanism—First and second voltage ranges	10129	10131
Electric lock	9929	9931
Interlocking lever circuit controller	13826	13831
Installation of made ground for protection against abnormal potentials	6017	6031
Line transformer, oil immersed, self-cooled	8419	8431
Transformer oil	4614	4631

Specifications Revised and Consolidated

Lead-covered cable	9120 & 9320	9131
Armored submarine cable	9020 & 9220	9031
Time-release	12729 & 12829	12831

New Specifications

Car retarder system	14731
Centralized traffic control system	14931
Centralized traffic control machine	15031
Plug type rail bonds and track circuit connectors	15131
Plug type porcelain insulators	14631

REPORT OF COMMITTEE XVII—WOOD PRESERVATION

F. C. SHEPHERD, *Chairman;*
WM. G. ATWOOD,
R. S. BELCHER,
Z. M. BRIGGS,
WALTER BUEHLER,
C. S. BURT,
G. B. CAMPBELL,
H. R. CONDON,
C. C. COOK,
E. A. CRAFT,
H. R. DUNCAN,
E. B. FULKS,
W. R. GOODWIN,
L. H. HARPER,
L. B. HOLT,
G. R. HOPKINS,
H. E. HORROCKS,
R. S. HUBLEY,
C. F. FORD, *Vice-Chairman;*
M. F. JAEGER,
W. H. KIRKBRIDE,
A. J. LOOM,
W. T. MACCART,
G. P. MACLAREN,
F. D. MATTOS,
CLYDE OSBORNE,
J. H. REEDER,
L. J. REISER,
L. B. SHIPLEY,
O. C. STEINMAYER,
G. C. STEPHENSON,
T. H. STRATE,
W. A. SUMMERHAYS,
C. M. TAYLOR,
DR. H. VON SCHRENK,
C. S. WILTSEE, JR.,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of Manual (Appendix A).

(2) Service Test Records for Treated Ties (Appendix B).

(3) Piling Used for Marine Construction (Appendix C).

(4) Destruction by Termite and Possible Ways of Prevention (Appendix D).

(5) Loss of Preservative in Treated Ties in Track due to Repeated Use of Oil Burning Weed Destroyers (Appendix E).

(6) Incising of Forest Products Material (Appendix F).

(7) Extent, if any, to which Decay is Permissible in Ties for Treatment, the Various Forms of Decay, and the Methods of Detecting Infection and Decay (Appendix G).

Action Recommended

1. That the information contained in Appendix A—Revision of Manual, be approved for publication in the Manual.

2. That the information contained in Appendix B—Service Test Records for Treated Ties; Appendix C—Piling Used for Marine Construction; Appendix D—Destruction by Termite and Possible Ways of Prevention; Appendix E—Loss of Preservative in Treated Ties in Track due to Repeated Use of Oil Burning Weed Destroyers; and Appendix F—Incising of Forest Products Material, be accepted as information.

3. That the information contained in Appendix G—Extent, if any, to which Decay is permissible in Ties for Treatment, the Various Forms of Decay, and the Methods of Detecting Infection and Decay, be accepted as information and the Committee discharged from any further consideration of this subject.

Respectfully submitted,

THE COMMITTEE ON WOOD PRESERVATION,
F. C. SHEPHERD, *Chairman.*

Bulletin 344, February, 1932.

Appendix A

(1) REVISION OF MANUAL

O. C. Steinmayer, Chairman, Sub-Committee; E. B. Fulks, R. S. Belcher, C. S. Burt, Walter Buehler, M. F. Jaeger, H. E. Horrocks, F. D. Mattos, G. C. Stephenson, L. B. Shipley, Dr. Hermann von Schrenk, C. S. Wiltsee, Jr.

Your Committee recommends that the present apparatus for determining coke residue in creosote oil, as appearing on page 1308 of the 1929 Manual, and reading as follows:

"The crucible shall be of platinum and shall have a capacity of 20 to 30 cc. The cover of the crucible shall be of the inverted type, having a depth of about 1 cm., the wall tightly fitting the crucible except for a slight crease."

be changed in accordance with the following for the purpose of obtaining more correct and consistent results in the coke-residue test:

"A platinum crucible shall be used, with tightly fitting cover of the inverted or capsule type having a depth of about 1 cm., provided with a hole 2 mm. in diameter at its center. The crucible shall have a capacity of 25 to 30 cc. and with cover shall weigh 25 to 30 grams."

Your Committee has found that in the determination of the specific gravities of creosote fractions, the Westphal balance, with special plummet or the weighing pan, as described on page 1303 of the 1929 Manual, under heading "Specific Gravity of Fractions" is not much used, but that the determinations are almost universally made by means of pycnometer bottles. Your Committee therefore recommends that the present specifications "(5) Specific Gravity of Fractions" be withdrawn and the following specifications submitted:

Standard Method for the Determination of the Specific Gravity 38°/15.5° C., of Creosote Fractions

Scope

1. This method is a convenient and accurate means of determining the specific gravity of the relatively small amounts of distillation fractions of creosote. It is also suitable for creosote oil and creosote coal tar solution where only small amounts are available.

Apparatus

2. Pycnometers, 10 and 25 ml. capacity with ground glass stoppers having the usual capillary openings water bath; thermometer, 0°–80° C., conforming to the specification given in "Standard Float Test of Residue in Creosote Oil."

Calibration of Pycnometer

3. Before making a determination, the pycnometer with stopper shall first be calibrated as follows: weigh the empty, clean, dry pycnometer with stopper upon an analytical balance; fill with freshly boiled distilled water, bring temperature to 38.0° C. in a water bath, insert stopper, wipe dry and weigh.

Procedure

4. Heat the fraction until completely liquid, and pour into the empty, dry pycnometer until full, avoiding the formation of air bubbles. Place the filled pycnometer in the water bath maintained at temperature of 38.0° C. ± 0.1°; after at least one-half hour immersion in bath, insert the stopper firmly, wipe clean and weigh. Use the 10 ml. bottle for the 315° — 355° C. fraction. The 25 ml. bottle may be used for the larger fraction.

Calculation

5. The expression "38°/15.5° C." means specific gravity taken at 38° C. compared with water at 15.5° C. This cannot be determined directly. The specific gravity is first determined at 38° C. and this determination represents the relation of the weight of a volume of oil at 38° C. to the weight of a volume at 38° C. to the weight of an equal volume of water at the same temperature. The relation to an equal volume of water at 15.5° C. is obtained by multiplying the former figure by .99393, the density of water at 38° C. compared to water at 15.5° C., $\frac{(.99299)}{(.99905)}$.

From the foregoing, it will be readily seen that it is incorrect to calculate the specific gravity at 38°/15.5° C. by dividing the weight of the oil taken at 38° C. by the weight of the water at 15.5° C.

An example is given herewith of the correct method of calculation where the weight of the specific gravity bottle is 23.7531; the weight of the bottle plus water at 38° C. is 78.1128; the weight of the bottle filled with oil at 38° C. is 80.2755:

$$\text{Specific Gravity at } 38°/38° \text{ C.} = \frac{80.2755 - 23.7531}{78.1128 - 23.7531} = 1.0398$$

$$\text{Corrected to } 38°/15.5° \text{ C.} = 1.0398 \times .99393 = 1.0335$$

Conclusion

It is recommended that this report be accepted and printed in the Manual.

Appendix B

(2) SERVICE TEST RECORDS FOR TREATED TIES

W. R. Goodwin, Chairman, Sub-Committee; Z. M. Briggs, C. S. Burt, E. A. Craft, L. B. Holt, R. S. Hubley, G. P. MacLaren, W. T. MacCart, T. H. Strate, J. H. Reeder.

The table of tie renewals per mile maintained on various railroads has been brought up to include renewals for 1930.

Reports are submitted covering special test tracks on the A. T. & S. F., B. & O., C. B. & Q., Canadian National, C. & N. W., C. M. & St. P., and Northern Pacific Railways.

Special Test Track

CANADIAN NATIONAL RAILWAYS

In July, 1930, the Canadian National Railways near Gananoque Junction, Ontario, installed the following ties for test:

88 Eastern Hemlock
92 Douglas Fir
93 Western Hemlock
95 Red Pine
77 Jack Pine
95 White Birch
97 Yellow Birch
95 Hard Maple
93 Beech
94 Red Oak

All ties are square sawn 7″ × 9″ — 8′ long. They were treated by the Forest Products Laboratories, at Ottawa, and were given ¼-lb. of Z.M.A. per cubic foot of timber. They are installed out of face in our west-bound track between Mile 154 and 155 on the Gananoque Sub-division.

STATEMENT SHOWING VARIOUS SPECIAL TIES ON A. T. & S. F. RY.

AS OF DECEMBER 31, 1930.

Station	Year Inserted	Original Number Inserted	Now in Track	Total Removed	% Ties Removed from track	Average Life to Date
	HEWN PINE ZINC CHLORIDE					
Turner-Holliday, Kans.	1918	4519	1509	3010	66.61	10.95
Newton, Kans.	1904	6357	0	6357	100.00	13.25
Newton, Kans.	1905	9251	216	9035	97.67	13.47
	SAWN PINE ZINC CHLORIDE					
Turner-Holliday, Kans.	1918	673	245	428	63.60	10.47
Newton, Kans.	1904	2517	33	2484	98.69	13.46
Newton, Kans.	1905	40	0	40	100.00	12.40
	HEWN PINE CREOSOTE					
Marceline, Mo.	1905	304	0	304	100.00	14.51
Turner-Holliday, Kans.	1918	6001	5175	826	13.76	11.83
Melvern, Kans.	1906	24238	11038	13200	54.46	22.02
Clements, Kans.	1904	165	18	147	89.09	19.35
Walton, Kans.	1917	10994	10713	281	2.56	12.90
Newton, Kans.	1913	149	139	10	6.71	16.87
Chilocco, Okla.	1919	10888	9421	1467	13.48	10.63
Chilocco, Okla.	1919	3267	3243	24	0.73	11.00
Ponca City, Okla.	1904	190	60	130	68.42	22.66
Perry, Okla.	1904	27	3	24	88.89	22.59
Mission-Hutchinson, Kans.	1909	107	107	none	0.00	21.00
St. John-Sylvia, Kans.	1910	40949	39130	1819	4.44	19.84
Lewis, Kans.	1910	13600	12594	1006	7.40	19.86
Justiceburg, Texas.	1911	1498	951	547	36.52	18.16
Texico-Lubbock, Texas.	1913	101173	91910	9263	9.16	16.85
	SAWN PINE CREOSOTE					
Turner-Holliday, Kans.	1918	1001	875	126	12.59	11.84
Garnett, Kans.	1905	384	118	266	69.27	18.58
Walton, Kans.	1917	1394	1366	28	2.01	12.96
Newton, Kans.	1913	151	145	6	3.97	16.94
Marland, Okla.	1904	275	50	227	81.81	20.85
Perry, Okla.	1904	366	76	290	79.23	22.02
Argonia, Kans.	1905	572	50	522	91.26	16.28
Mission-Hutchinson, Kans.	1909	68	68	none	0.00	21.00
St. John-Sylvia, Kans.	1910	9436	5865	3571	37.84	18.43
Texico-Lubbock, Tex.	1913	162344	144147	18197	11.21	16.89
	SAWN SAP PINE CREOSOTE					
Justiceburg, Texas.	1911	372	108	264	70.97	15.36
	SAWN HEART PINE CREOSOTE					
Justiceburg, Texas.	1911	387	365	22	5.68	18.88
	HEWN WHITE OAK CREOSOTE					
Justiceburg, Texas.	1911	373	309	64	17.16	18.43

Sheet #2.

Station	Year Inser-ted	Original Number Inserted	Now in Track	Total Re-Moved	% Ties Removed from Track	Average Life to Date
		HEWN RED OAK CREOSOTE				
Turner-Holliday, Kans.	1918	2733	2704	29	1.06	11.99
Newton, Kans.	1913	150	149	1	0.67	16.93
Walton, Kans.	1917	4395	4299	96	2.18	12.92
Justiceburg, Tex.	1911	229	197	32	13.97	18.47
Texico-Lubbock, Tex.	1913	162	136	26	16.05	16.88
		SAWN RED OAK CREOSOTE				
Plevna, Kans.	1907	52	6	46	88.46	15.40
Justiceburg, Tex.	1911	294	210	84	28.57	17.12
		HEWN GUM CREOSOTE				
St. John-Sylvia, Kans.	1909	1353	1335	18	1.35	20.97
St. John-Sylvia, Kans.	1910	13463	13436	27	0.20	20.00
Justiceburg, Texas.	1911	378	325	53	14.02	18.40
		SAWN GUM CREOSOTE				
Newton, Kans.	1913	150	132	18	12.00	16.64
Hutchinson, Kans.	1907	390	220	170	43.59	21.26
Hutchinson, Kans. M.L.	1907	230	94	136	59.13	20.71
Plevna, Kans.	1907	262	135	127	48.47	19.08
Justiceburg, Tex.	1911	353	241	112	31.73	17.25
		DOUGLAS FIR CREOSOTE				
Barstow, Calif.	1910	17108	1467	15641	91.43	15.96
		SAWN BEECH CREOSOTE				
Smithshire, Ill.	1912	384	356	28	7.29	17.56
Marceline, Mo.	1912	99	87	12	12.12	17.91
Tecumseh, Kans.	1912	161	0	161	100.00	16.52
Newton, Kans.	1912	151	144	7	4.64	17.92
Justiceburg, Texas.	1911	318	257	61	19.18	17.83
		HEWN ENGELMANN SPRUCE CREOSOTE				
Pinta, Arizona	1927	892	892	None	0.00	3.00
		SAWN ENGELMANN SPRUCE CREOSOTE				
Pinta, Arizona	1927	1023	1023	None	0.00	3.00
		HEWN TEXAS PINE 70% CREOSOTE 30% PETROLEUM 7#				
Elinor, Kans.	1923	12920	12920	None	0.00	7.00
Elinor, Kans.	1924	142	142	None	0.00	6.00
Mission-Hutchinson, Kans.	1923	27663	27663	None	0.00	7.00
Mission-Hutchinson, Kans.	1925	51	51	None	0.00	5.00
		SAWN TEXAS PINE 70% CREOSOTE 30% PETROLEUM 7#				
Mission-Hutchinson, Kans.	1923	11734	11734	None	0.00	7.00
		SAWN RED OAK 70% CREOSOTE 30% PETROLEUM 7#				
Mission-Hutchinson, Kans.	1923	1043	1043	None	0.00	7.00

Sheet #3.

Station	Year Inserted	Original Number Inserted	Now in Track	Total Removed	% Ties Removed from track	Average Life to Date
HEWN GUM 70% CREOSOTE 30% PETROLEUM 7#						
Elinor, Kans.	1924	153	153	None	0.00	6.00
SAWN GUM 70% CREOSOTE 30% PETROLEUM 7#						
Elinor, Kans.	1923	2775	2775	None	0.00	7.00
Elinor, Kans.	1924	145	145	"	0.00	6.00
Chillicothe, Ill.	1926	365	365	"	0.00	4.00
HEWN TEXAS PINE 70% CREOSOTE COAL TAR SOLUTION 30% PETROLEUM 8#						
Chillicothe, Ill.	1925	2735	2735	None	0.00	5.00
Chillicothe, Ill.	1926	1910	1910	"	0.00	4.00
HEWN COTTONWOOD CREOSOTE 5#						
Lucy, New Mexico	1923	75	75	None	0.00	7.00
SAWN COTTONWOOD CREOSOTE 5#						
Lucy, New Mexico	1923	75	73	2	2.67	7.00
HEWN COTTONWOOD 50% CREOSOTE 50% PETROLEUM 7#						
Lucy, New Mexico	1923	75	75	None	0.00	7.00
SAWN COTTONWOOD 50% CREOSOTE 50% PETROLEUM 7#						
Lucy, New Mexico	1923	75	75	None	0.00	7.00
HEWN TEXAS PINE 50% CREOSOTE 50% PETROLEUM 8#						
Elinor, Kans.	1924	8426	8426	None	0.00	6.00
Mission-Hutchinson, Kans.	1928	365	365	None	0.00	2.00
Mission-Hutchinson, Kans.	1929	26733	26733	None	0.00	1.00
Mission-Hutchinson, Kans.	1930	130	130	None	0.00	0.00
SAWN TEXAS PINE 50% CREOSOTE 50% PETROLEUM 8#						
Mission-Hutchinson, Kans.	1927	24	24	None	0.00	3.00
Mission-Hutchinson, Kans.	1928	3180	3180	None	0.00	2.00
Mission-Hutchinson, Kans.	1929	5866	5866	None	0.00	1.00
SAWN GUM 50% CREOSOTE 50% PETROLEUM 8#						
Chillicothe, Ill.	1926	53	53	None	0.00	4.00
Elinor, Kans.	1924	143	143	None	0.00	6.00
SAWN ARIZONA PINE 50% CREOSOTE 50% PETROLEUM						
Texico-Lubbock, Tex.	1913	8259	8001	258	3.12	16.90

THE BALTIMORE & OHIO RAILROAD COMPANY

Herring Run, Md.

1 9 3 1 I N S P E C T I O N

AGE OF TEST - SEVENTEEN YEARS

KIND OF WOOD - RED OAK

Sec. No.	Tie Numbers	Process	Per Cu. Ft.	Ties Placed Note	Ties in Test Note	Removed to date No.	Removed to date %	Average Life to Date of Ties in Test
1	3-300	Untreated		298	289	289	100.0	5.1
2	301-600	Burnettizing	0.35# Zinc Chl.	300	161	143	88.8	12.4
3	601-900	"	0.63# " "	300	211	127	60.2	13.9
4	901-1200	Straight Creo.	4.02# Creo.	300	300	124	41.3	15.1
5	1201-1500	" "	9.78# "	300	300	20	6.7	16.8
6	1501-1650	Straight W.G. Tar Creo.	5.16# W.G. Tar Creo.	150	150	70	46.6	15.5
7	1651-1800	Ditto	6.12# Ditto	150	150	63	42.0	15.7
8	1801-1950	"	7.09# "	150	150	102	68.0	14.3
9	1951-2100	"	10.90# "	150	150	76	50.6	15.2
10	0-212 Cull	"	11.00# "	212	212	143	67.5	14.0
11	2101-2400	Sodium Fluoride	0.41# Sod. Flu.	300	300	221	73.7	14.2
12	2401-2700	Card	(0.63# Zinc. Chl. (0.76# Creo.	300	300	261	87.0	13.0
13	2701-3000	Card	(0.69# Zinc Chl. (1.35# W.G.Tar (Creo. (0.37# Creo.	300	300	172	57.4	14.8
14	3001-3300	Card	(0.5# Zinc Chl. (2.0# Creo.	300	288	232ø	80.6	ø12.8

Note: The difference between Ties Placed and Ties in Test is due to, elimination from test of ties account of removals from derailments and installation of switches.

ø : This group installed 9 months (.75 year) after other ties in this test.

SPECIAL TEST TRACKS

BALTIMORE & OHIO RAILROAD COMPANY

1931 INSPECTION

WINDSOR - BLANCHESTER, OHIO

AGE OF TIE TEST - TWENTY ONE YEARS

Treatment and Kind of Wood	Ties Placed	Ties in Test	Removed to date No.	Removed to date %	Average Life to Date of Ties in Test	Remaining in Track Est. Add'l. Average Life No.	Remaining in Track Est. Add'l. Average Life Years	Anticipated Average Total Life of all Ties in Test
	NOTE	NOTE						
UNTREATED								
White Oak	757	757	742	98	10.19	15	1.6	10.21
STRAIGHT CREOSOTE								
Red Oak	873	820	68	8.3	20.61	752	3.82	23.42
*Other Woods	252	252	121	46.9	17.56	131	6.0	20.29
CARD PROCESS								
Red Oak	1125	1125	441	39.2	18.77	684	2.9	20.07
*Other Woods	1219	1206	695	57.6	16.93	511	2.5	17.66
TIMBER ASPHALT								
Red Oak	984	969	962	99.2	10.7	7	2.1	10.7

NOTE: The difference between "Ties Placed" and Ties in Test" is due to elimination from test of ties account of removals from derailments.

* Other woods - Beech, Hard Maple, Gum, and Elm.

ITEM		ANNUAL AVERAGE
Traffic -	Gross Tons (Thousands)	5,210
Temperature -	(Mean January)	30.33
Fahrenheit -	Mean July	74.52
	- Highest Annual	96.2
	- Lowest Annual	5.6
Rainfall	- Inches	40.2

SUMMARY OF 1930 INSPECTION OF CROSS TIE TEST TRACKS

C. B. & Q. R. R.

RESULTS OF TWENTY ONE YEARS' SERVICE

	Lines East					Lines West				
Process	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes	Estimated Years Aver. Life	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes	Estimated Years Average Life
Creosote	2,045	729	12	23	25	1,236	592	13	35	23
Card	10,244	6,772	24	42	21	5,593	4,306	29	48	19
Burnett	1,578	1,335	51	33	18	909	861	45	50	16
Untreated	2,045	2,036	90	9	5.78	1,225	1,222	91	9	5.78

Note: *These percentages include only the ties placed in what are termed the thousand-tie lots on the various divisions.*

AVERAGE LIFE OF UNTREATED TIES (IN YEARS)

Cottonwood...2.93	Red Gum......4.17	Tamarack.......5.37	Hickory.... 5.72
Tupelo Gum...3.45	Hard Maple...4.86	Ash...........5.38	Pin Oak.... 6.63
Sycamore.....3.59	Beech........5.05	White Elm......5.54	Cypress.... 8.54
Soft Maple...3.93	Hemlock......5.23	Loblolly Pine..5.58	Chestnut... 9.43
Red Birch....3.94	Poplar.......5.33	Red Oak........5.61	White Oak..11.51

1930 INSPECTION OF CROSS TIE TEST TRACKS C. B. & Q. R. R.

RESULTS OF TWENTY ONE YEARS' SERVICE.

	Lines East				Lines West			
Process	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes
				ASH TIES				
Creosote	19	16	26	58	16	11	25	44
Card	289	203	15	55	103	78	18	57
Burnett	16	11	38	31	15	13	33	53
Untreated	70	70	99	1	45	45	100	00
				BEECH TIES				
Creosote	321	62	5	18	163	41	43	21
Card	807	637	37	42	420	346	35	47
Burnett	210	180	53	32	105	97	52	40
Untreated	134	134	99	1	74	74	97	3
				BIRCH TIES				
Creosote	75	25	24	9	59	24	14	27
Card	715	483	30	38	360	271	31	44
Burnett	73	73	56	44	30	30	43	57
Untreated	139	139	100	--	78	78	100	00
				CHESTNUT TIES				
Creosote	--	--	--	--	--	--	--	--
Card	164	161	15	83	89	89	9	91
Burnett	00	--	--	--	--	--	--	--
Untreated	169	167	35	64	90	89	21	78

Sheet #2.

	Lines East				Lines West			
Process	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes
COTTONWOOD TIES								
Creosote	88	26	1	28	45	14	11	20
Card	296	191	20	45	160	125	21	57
Burnett	--	--	--	--	--	--	--	--
Untreated	56	56	95	5	30	30	100	--
CYPRESS TIES								
Creosote	25	3	--	12	29	20	44	24
Card	409	262	9	56	254	192	24	52
Burnett	25	14	8	48	30	29	47	50
Untreated	135	132	78	20	90	90	89	11
ELM TIES								
Creosote	208	59	14	14	120	37	7	24
Card	594	317	19	35	371	223	24	36
Burnett	224	164	45	29	73	66	55	36
Untreated	113	113	93	7	78	78	96	4
HEMLOCK TIES								
Creosote	136	86	24	40	99	76	21	56
Card	816	576	24	47	488	427	36	51
Burnett	125	97	41	37	87	79	33	57
Untreated	112	112	100	--	78	78	99	1
HICKORY TIES								
Creosote	10	2	10	10	15	6	7	33
Card	185	163	30	58	105	93	39	50
Burnett	9	3	--	33	15	14	47	47
Untreated	65	65	91	9	45	45	100	00
PINE TIES, LOBLOLLY OR SAP								
Creosote	145	52	6	30	72	49	17	51
Card	949	561	26	33	386	304	24	55
Burnett	128	125	73	24	72	70	46	51
Untreated	157	157	99	1	91	91	100	--
HARD MAPLE TIES								
Creosote	82	21	16	10	34	17	6	44
Card	561	299	23	30	272	205	30	46
Burnett	50	35	44	26	15	15	87	13
Untreated	76	76	99	1	45	45	100	--
SOFT MAPLE TIES								
Creosote	139	86	33	29	62	29	21	26
Card	462	343	38	36	264	182	20	49
Burnett	125	122	66	31	57	55	35	61
Untreated	82	82	100	--	43	43	95	5
WHITE OAK TIES								
Creosote	25	2	--	8	15	9	20	40
Card	234	191	34	47	152	128	28	57
Burnett	28	25	64	25	15	15	40	60
Untreated	81	78	85	11	44	43	80	18

Sheet #3

	Lines East				Lines West			
Process	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes	Total Placed	Total Removed to Date	% Removed a/c Decay	% Removed a/c Other Causes
RED OAK TIES								
Creosote	165	44	4	22	120	56	12	35
Card	776	472	17	43	508	444	32	56
Burnett	158	129	47	34	116	107	41	52
Untreated	129	129	96	4	75	74	92	7
PIN OAK TIES								
Creosote	189	47	6	19	132	34	8	17
Card	513	252	14	35	321	214	22	45
Burnett	23	9	22	17	44	43	32	66
Untreated	81	80	96	2	45	45	96	4
POPLAR TIES								
Creosote	50	17	8	26	30	24	17	63
Card	396	313	31	48	253	216	36	49
Burnett	50	44	46	42	30	30	57	43
Untreated	81	81	93	7	45	45	98	2
RED GUM TIES								
Creosote	89	52	24	35	48	32	25	42
Card	429	263	27	34	233	152	32	33
Burnett	75	73	64	33	43	41	70	26
Untreated	98	98	97	3	54	54	98	2
SYCAMORE TIES								
Creosote	75	23	17	13	15	2	--	13
Card	399	218	38	17	121	109	62	28
Burnett	75	73	80	17	15	15	80	20
Untreated	81	81	98	2	50	50	96	4
TAMARACK TIES								
Creosote	106	57	7	47	108	82	14	62
Card	813	659	20	61	496	435	30	57
Burnett	108	88	34	47	106	101	28	67
Untreated	98	98	96	4	77	77	100	00
TUPELO GUM TIES								
Creosote	98	49	18	32	54	29	17	37
Card	437	208	14	33	237	73	13	18
Burnett	76	70	42	50	41	41	61	39
Untreated	88	88	99	1	48	48	98	2

Sheet #4

Station	Year Inserted	Original Number Inserted	Now in Track	Total Removed	% Ties Removed from Track	Average Life to Date
		SAWN ARIZONA 45% CREOSOTE 55% PETROLEUM 8#				
Pinta, Arizona	1927	2266	2266	None	0.00	3.00
		SAWN ARIZONA PINE 45% CREOSOTE 55% PETROLEUM 8# STEAMED 2 HOURS 20#				
Pinta, Arizona	1927	441	441	None	0.00	3.00
		SAWN ARIZONA PINE 45% CREOSOTE 55% PETROLEUM 8# STEAMED 2 HOURS 30#				
Pinta, Arizona	1927	453	453	None	0.00	3.00
		HEWN ARIZONA PINE 45% CREOSOTE 55% PETROLEUM 8#				
Pinta, Arizona	1927	1859	1859	None	0.00	3.00
		HEWN ENGELMANN SPRUCE 45% CREOSOTE 55% PETROLEUM 8#				
Pinta, Arizona	1927	906	906	None	0.00	3.00
		SAWN ENGELMANN SPRUCE 45% CREOSOTE 55% PETROLEUM 8#				
Pinta, Arizona	1927	1174	1174	None	0.00	3.00
		HEWN ARIZONA PINE 25% CREOSOTE 75% PETROLEUM 8#				
Acomita, New Mexico	1924	998	997	1	0.10	6.00
		HEWN TEXAS PINE 25% CREOSOTE 75% PETROLEUM 8#				
Whiteface, Texas	1925	557	557	None	0.00	5.00
Boise City, Kans.	1925	546	546	None	0.00	5.00
Acomita, New Mexico	1924	999	999	None	0.00	6.00
		HEWN GUM 25% CREOSOTE 75% PETROLEUM 8#				
Boise City, Kans.	1925	261	261	None	0.00	5.00
Whiteface, Texas.	1925	254	254	None	0.00	5.00
		SAWN ARIZONA PINE 25% CREOSOTE 75% PETROLEUM 8#				
Pinta, Arizona	1927	503	503	None	0.00	3.00
		SAWN ARIZONA PINE 25% CREOSOTE 75% PETROLEUM 8# STEAMED 2 HOURS 20#				
Pinta, Arizona	1927	439	439	None	0.00	3.00
		SAWN ARIZONA PINE 25% CREOSOTE 75% PETROLEUM 8# STEAMED 2 HOURS 30#				
Pinta, Arizona	1927	461	461	None	0.00	3.00
		HEWN OHIO UNTREATED				
Stafford, Kans.	1910	132	90	42	31.82	17.66
		SAWN OHIO UNTREATED				
Stafford, Kans.	1910	108	80	28	25.93	17.87

Condition of experimental ties in the Chicago and Northwestern Railway test track near Janesville, Wis., after about 24 years service.

Ties set December 1907 — Ties inspected October 1931

Species	Preservative	Treatment	Total no. of ties in test	Good: Number	Good: Per cent	Split: Number	Split: Per cent	Decayed and split: Number	Decayed and split: Per cent	Partly decayed: Number	Partly decayed: Per cent	Badly decayed: Number	Badly decayed: Per cent	Removed: Account of decay: Number	Removed: Account of decay: Per cent	Removed: For causes other than decay[1]: Number	Removed: For causes other than decay[1]: Per cent	Removed: Cause unknown: Number	Removed: Cause unknown: Per cent
Hemlock	Zinc chloride	Burnett	25	--	--	--	--	4	16.0	--	--	--	--	17[a]	68.0	2	8.0	2	8.0
Hemlock	Zinc chloride - glue and tannin	Wellhouse	1530[b]	--	--	5	0.3	539	35.2	2	0.1	1	0.1	[illegible]29[c]	54.2	107	7.0	47	3.1
Hemlock	Creosote	Open tank	33	--	--	--	--	7	21.2	--	--	--	--	[illegible][d]	60.6	2	6.1	2	6.1
Hemlock[2]	Untreated	--	169	--	--	--	--	--	--	--	--	--	--	169	100.0	--	--	--	--
Tamarack	Zinc chloride	Burnett	388	--	--	3	0.8	138	35.5	--	--	--	--	192[e]	49.5	40	10.3	15	3.9
Tamarack	Zinc chloride - glue and tannin	Wellhouse	738	--	--	1	0.1	204	27.7	--	--	1	0.1	453[f]	61.4	49	6.6	30	4.1
Tamarack	Creosote	Open tank	19	--	--	--	--	10	52.6	--	--	--	--	9[g]	47.4	--	--	--	--
Tamarack[3]	Untreated	--	125	--	--	--	--	--	--	--	--	--	--	125	100.0	--	--	--	--
White oak[4]	Untreated	--	50	--	--	--	--	--	--	--	--	--	--	50	100.0	--	--	--	--

[1] Splitting, mechanical wear, etc.
[2] Average life 6.5 years
[3] Average life 6.2 years
[4] Average life 10.1 years

[a] 1 tie removed account of combination of decay and other causes
[b] 5 ties eliminated from experiment to date
[c] 287 ties removed account of combination of decay and other causes
[d] 2 ties removed account of combination of decay and other causes
[e] 109 ties removed account of combination of decay and other causes
[f] 189 ties removed account of combination of decay and other causes
[g] 5 ties removed account of combination of decay and other causes

Summary by treatments (Irrespective of species)

Preservative	Treatment	Total no. of ties in test	Good: Number	Good: Per cent	Split: Number	Split: Per cent	Decayed and split: Number	Decayed and split: Per cent	Partly decayed: Number	Partly decayed: Per cent	Badly decayed: Number	Badly decayed: Per cent	Removed: Account of decay: Number	Removed: Account of decay: Per cent	Removed: For causes other than decay[1]: Number	Removed: For causes other than decay[1]: Per cent	Removed: Cause unknown: Number	Removed: Cause unknown: Per cent
Zinc chloride	Burnett	413	--	--	3	0.7	142	34.4	--	--	--	--	209[h]	50.6	42	10.2	17	4.1
Zinc chloride - glue and tannin	Wellhouse	2268[b]	--	--	6	0.3	743	32.7	2	0.1	2	0.1	1282[j]	56.5	156	6.9	77	3.4
Creosote	Open tank	52	--	--	--	--	17	32.7	--	--	--	--	31[k]	59.7	2	3.8	2	3.8

[1] Splitting, mechanical wear, etc.

[b] 5 ties eliminated from test
[h] 109 ties removed account of combination of decay and other causes
[j] 476 ties removed account of combination of decay and other causes
[k] 7 ties removed account of combination of decay and other causes.

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
December 14, 1931

Table 1. -- Condition of experimental ties in the Chicago, Milwaukee, St. Paul and Pacific Railway test track near the Fair Grounds, Madison, Wis.

Results of 1931 inspection

le / os.	Species	Preservative	Average absorption	Number of ties set	Number of ties in test	Date set	Years service	Good		Split		Partly decayed		Badly decayed		Decayed and split		Removed: Account of decay		Removed: For causes other than decay		Missing
			Lbs. per cu. ft.					Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number
-398	Douglas fir (Coast)	Creosote	11.50	29	29	October 1917	14	27	93.1	2	6.9	--	--	--	--	--	--	--	--	--	--	--
-599	Red oak	Zinc chloride	0.55	200	185	November 1916	15	12	6.5	10	5.4	43	23.2	41	22.2	30	16.2	44[a]	23.8	5	2.7	15
-699	Red oak	25% creosote and 75% gas oil	10.20	100	99	November 1916	15	44	44.5	48	48.5	1	1.0	--	--	4	4.0	2[b]	2.0	--	--	1
-798	Red oak	10% creosote and 90% gas oil	10.00	99	98	November 1916	15	52	53.1	34	34.7	4	4.1	--	--	6	6.1	1	1.0	1	1.0	1
-42[c]	Douglas fir (Coast)	Untreated	--	42	38	October 1917	--[c]	--	--	--	--	--	--	--	--	--	--	36[d]	94.7	2	5.3	4
900	White oak	Untreated	--	100	95	October 1917	14	--	--	--	--	6	6.3	4	4.2	6	6.3	78[e]	82.1	1	1.1	5
-1100	Red oak	Sodium fluoride	0.52	100	99	October 1917	14	2	2.0	2	2.0	84	84.9	--	--	10	10.1	1[b]	1.0	--	--	1
-1200	Red oak	Water gas tar	9.79	100	100	October 1917	14	67	67.0	33	33.0	--	--	--	--	--	--	--	--	--	--	--
-1250	Western larch	Untreated	--	50	44	October 1917	14	1	2.3	1	2.3	3	6.8	1	2.3	--	--	37[f]	84.0	1[g]	2.3	6
-1300	Douglas fir (Coast)	Untreated	--	50	48	October 1917	14	4	8.3	2	4.2	6	12.5	--	--	6	12.5	27[h]	56.3	3	6.2	2
-1405	Douglas fir (Coast)	Zinc chloride	0.52	105	105	September 1919	12	9	8.6	19	18.1	27	25.7	--	--	42	40.0	4[j]	3.8	4	3.8	--
-1500	Western larch	Zinc chloride	0.48	95	95	September 1919	12	27	28.4	15	15.8	10	10.5	--	--	35	36.9	6[k]	6.3	2	2.1	--
-1563	Red oak	50% C.T.creosote & 50% W.T.creosote	9.50	62	62	September 1919	12	42	67.8	19	30.6	1	1.6	--	--	--	--	--	--	--	--	--
1586	Slippery elm	50% C.T.creosote & 50% W.T.creosote	10.85	25	25	September 1919	12	4	16.0	21	84.0	--	--	--	--	--	--	--	--	--	--	--
1591-1598	Butternut	50% C.T.creosote & 50% W.T.creosote	9.00	9	9	September 1919	12	1	11.1	5	55.6	--	--	--	--	3	33.3	--	--	--	--	--
92	White oak	50% C.T.creosote & 50% W.T.creosote	7.30	1	1	September 1919	12	1	100.0	--	--	--	--	--	--	--	--	--	--	--	--	--
1599-00	Cherry	50% C.T.creosote & 50% W.T.creosote	10.50	3	3	September 1919	12	1	33.3	2	66.7	--	--	--	--	--	--	--	--	--	--	--
1700	Red oak	Wood tar creosote	10.08	100	100	September 1919	12	40	40.0	42	42.0	6	6.0	--	--	11	11.0	1	1.0	--	--	--
1800	Red oak	Low temperature coal tar oil	10.30	100	100	October 1921	10	52	52.0	48	48.0	--	--	--	--	--	--	--	--	--	--	--
1900	Red oak	50% tar & 50% low temp.coal tar oil	10.50	100	100	October 1921	10	65	65.0	35	35.0	--	--	--	--	--	--	--	--	--	--	--
2000	Red oak	Vertical retort coal tar creosote	9.60	100	100	October 1921	10	75	75.0	25	25.0	--	--	--	--	--	--	--	--	--	--	--
2100	Red oak	Pintsch gas tar	10.50	100	85	October 1921	10	58	68.2	27	31.8	--	--	--	--	--	--	--	--	--	--	15[m]
2480	Jack pine	Zinc chloride	0.52	381	371	June 1927	4	365	98.4	5	1.3	1	0.3	--	--	--	--	--	--	--	--	10[n]

12 ties removed account of combination of decay and other causes.
1 tie " " " " " " "
Switch ties -- average life based on 38 ties -- 6.5 years
Sixteen ties removed 1924. These ties not available for inspection after removal but on basis of previous records it is assumed that they were removed on account of decay and rail cutting.
11 ties removed account of combination of decay and other causes
6 " " " " " " " " " "
Cause of removal not determined
3 ties removed account of combination of decay and other causes
4 " " " " " " " " " "
5 " " " " " " " " " "
Except 1536 which is cherry
15 ties under temporary crossing - not inspected
10 " " " " " "

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
Proj. L-213 - December 12, 1931.

Condition of experimental ties in the Chicago, Milwaukee, St. Paul and Pacific Railway test track near Hartford, Wis., after about twenty years service.

Ties set October 1911 — Ties inspected October 1931

ers	Species	Preservative	Process	Tie plates	Total no. of ties in test	Good		Split		Partly decayed		Decayed and split		Badly decayed		Removed: Account of decay		Removed: For causes other than decay		Removed: Cause unknown	
						Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
933[a]	Chestnut	Zinc chloride	Burnett (Commercial)[b]	Flat steel	10	--	--	--	--	1	10.0	--	--	--	--	8[o]	80.0	--	--	1	10.0
947[d]	Chestnut	Zinc chloride	Burnett (Commercial)[b]	Ribbed mal. iron	13	--	--	--	--	--	--	1	7.7	--	--	7[c]	53.8	5	38.5	--	--
550	Maple	Creosote	Full cell	None	50	6	12.0	34	68.0	--	--	10	20.0	--	--	--	--	--	--	--	--
600	Maple	Creosote	Full cell	Flat steel	49[e]	9	18.4	38	77.6	1	2.0	1	2.0	--	--	--	--	--	--	--	--
450	Maple	Creosote	Rueping	Flat steel	50	8	16.0	36	72.0	--	--	6	12.0	--	--	--	--	--	--	--	--
500	Maple	Creosote	Rueping	None	50	7	14.0	39	78.0	--	--	4	8.0	--	--	--	--	--	--	--	--
1150	Maple	20% creosote, 80% zinc chloride	Card	None	50	8	16.0	33	66.0	2	4.0	6	12.0	--	--	1[f]	2.0	--	--	--	--
1200	Maple	20% creosote, 80% zinc chloride	Card	Flat steel	50	1	2.0	34	68.0	--	--	15	30.0	--	--	--	--	--	--	--	--
1450	Maple	Semi-refined paraffin oil	Full cell	Flat steel	50	--	--	35	70.0	1	2.0	12	24.0	--	--	1	2.0	1	2.0	--	--
1500	Maple	Semi-refined paraffin oil	Full cell	None	49[g]	--	--	42	85.7	--	--	7	14.3	--	--	--	--	--	--	--	--
1050	Maple	Zinc chloride-creosote	Two movement	Flat steel	50	4	8.0	35	70.0	1	2.0	8	16.0	--	--	2	4.0	--	--	--	--
1100	Maple	Zinc chloride-creosote	Two movement	None	50	4	8.0	20	40.0	--	--	13	26.0	--	--	13[f]	26.0	--	--	--	--
350	Maple	Zinc chloride	Burnett (Lab. treated)	None	49[h]	--	--	--	--	--	--	14	28.6	--	--	24[j]	49.0	--	--	11	22.4
400	Maple	Zinc chloride	Burnett (Lab. treated)	Flat steel	50	--	--	2	4.0	2	4.0	29	58.0	--	--	15[k]	30.0	--	--	2	4.0
1550	Maple[1]	Untreated	---	None	50	--	--	--	--	--	--	--	--	--	--	50[f]	100.0	--	--	--	--
1600	Maple[2]	Untreated	---	Flat steel	50	--	--	--	--	--	--	--	--	--	--	50	100.0	--	--	--	--
150[l]	Red oak	Creosote	Full cell	None	52	26	50.0	25	48.1	--	--	--	--	--	--	--	--	1	1.9	--	--
-200	Red oak	Creosote	Full cell	Flat steel	50	25	50.0	23	46.0	--	--	1	2.0	--	--	--	--	1	2.0	--	--
-50	Red oak	Creosote	Rueping	Flat steel	50	23	46.0	21	42.0	1	2.0	4	8.0	--	--	1	2.0	--	--	--	--
-100	Red oak	Creosote	Rueping	None	50	20	40.0	26	52.0	1	2.0	--	--	--	--	2[f]	4.0	1	2.0	--	--
-1250	Red oak	20% creosote, 80% zinc chloride	Card	None	50	15	30.0	13	26.0	13	26.0	6	12.0	--	--	1[f]	2.0	2	4.0	--	--
-1300	Red oak	20% creosote, 80% zinc chloride	Card	Flat steel	50	14	28.0	11	22.0	11	22.0	14	28.0	--	--	--	--	--	--	--	--
-650	Red oak	Semi-refined paraffin oil	Full cell	Flat steel	50	6	12.0	12	24.0	22	44.0	7	14.0	2	4.0	1	2.0	--	--	--	--
-700	Red oak	Semi-refined paraffin oil	Full cell	None	49[g]	6	12.3	13	26.5	13	26.5	15	30.7	1	2.0	1	2.0	--	--	--	--
-850	Red oak	Zinc chloride-creosote	Two movement	Flat	50	13	26.0	16	32.0	3	6.0	14	28.0	1	2.0	3	6.0	--	--	--	--
-900	Red oak	Zinc chloride-creosote	Two movement	None	50	5	10.0	16	32.0	3	6.0	22	44.0	--	--	1	2.0	3	6.0	--	--
-2154	Red oak	Zinc chloride	Burnett (commercial)[b]	Flat steel	157[m]	--	--	--	--	3	1.9	28	17.8	22	14.0	93[n]	59.3	2	1.3	9	5.7
-1350	Red oak	Zinc chloride	Burnett (commercial)[b]	Flat steel	49[o]	--	--	--	--	1	2.0	11	22.5	11	22.5	24[f]	49.0	--	--	2	4.0
-1400	Red oak	Zinc chloride	Burnett (commercial)[b]	Ribbed mal. iron	53[p]	--	--	--	--	4	7.5	10	18.9	12	22.6	24[j]	45.3	--	--	3	5.7
-250	Red oak	Zinc chloride	Burnett (Lab. treated)	None	50	--	--	--	--	13	26.0	23	46.0	8	16.0	5	10.0	--	--	1	2.0
-300	Red oak	Zinc chloride	Burnett (Lab. treated)	Flat steel	50	--	--	--	--	23	46.0	17	34.0	5	10.0	3[f]	6.0	--	--	2	4.0
-750	Red oak[3]	Untreated	--	None	50	--	--	--	--	--	--	--	--	--	--	50[f]	100.0	--	--	--	--
-800	Red oak[4]	Untreated	--	Flat steel	50	--	--	--	--	--	--	--	--	--	--	50	100.0	--	--	--	--
-913	Spruce	Mercuric chloride	Kyan	Flat steel	13	--	--	4	30.8	--	--	5	38.4	--	--	4[f]	30.8	--	--	--	--
-925	Spruce	Mercuric chloride	Kyan	None	12	--	--	1	8.3	--	--	4	33.4	--	--	6	50.0	1	8.3	--	--

[a] Also ties no. 2004 and 2067
[b] Obtained from regular stock of C.M.St.P.&P.Ry.
[c] 5 ties removed account of combination of decay and other causes
[d] Tie no. 944 not placed in track
[e] Tie no. 538 eliminated
[f] 1 tie removed account of combination of decay and other causes
[g] 1 tie removed for oil analysis
[h] Tie no. 319 eliminated
[j] 8 ties removed account of combination of decay and other causes
[k] 2 ties removed account of combination of decay and other causes
[l] 2 duplicates (109 and 116)
[m] 8 duplicates (Ties no 2004 and 2067 are chestnut)
[n] 10 ties removed account of combination of decay and other causes
[o] 1 tie missing
[p] Includes tie No. 2001, 2002 and 2003

[1] Average life 6.4 years
[2] Average life 7.8 years
[3] Average life 8.7 years
[4] Average life 9.2 years

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
December 14, 1931

1931 INSPECTIONS

NORTHERN PACIFIC RAILWAY COMPANY

RECORD TEST TRACK NO. 1–A

LOCATION.—M.P. 89, near Rice, to M.P. 103½, near Gregory, Minn. In eastward main track on St. Paul Division. Ties laid in spring of 1917. Established as record test track January 10th, 1922.

TIES.—44,159 Hewed Minnesota Tamarack.

TREATMENT.—Brainerd Tie Treating Plant, December 1916. Air seasoned. Bored and adzed for 90-lb. rail. Treated by Lowry Process. 6¾-lb. per cubic foot with creosote-coal tar solution, 80 per cent creosote and 20 per cent refined coal tar.

TRACK.—Originally 90-lb. rail with N.P. Standard angle bars and 7″ × 9″ tie plates. Average gravel ballast about six inches under the ties. In 1923 about three and a half miles of washed gravel from Darling Pit was placed on the east end of this track. In 1928 four miles (M.P. 93½ to 97½) were relaid with 100-lb. rail and 7¾″ × 10¾″ tie plates.

RENEWALS.—No renewals up to 1928.

1928—1 tie account decay. Showed signs of having been partially decayed when treated.

1929—239 ties account derailment.

1930—No renewals.

1931—3 ties account decay.

Total Renewals 243 ties, 0.55 per cent after 14 years.

Conclusion

It is recommended that this report be accepted as information and the subject continued.

INSPECTION OF RED OAK TIES, LOUISVILLE & NASHVILLE RAILROAD TREATED WITH HEAVY CREOSOTE—1918

By S. R. CHURCH

This report concerns the inspection of some creosoted red oak ties laid in the Louisville & Nashville Railroad in 1918, and the analysis of the creosote originally used in comparison with the creosote extracted from two of these ties after 13 years' service.

In the Summer of 1917, 50,000 gallons of heavy creosote were shipped by the Barrett Company from its plant at Fairfield, Alabama, to the Louisville & Nashville Treating Plant at Guthrie, Ky., for the purpose of determining whether ties could be satisfactorily treated with this creosote in comparison as to penetration, etc., with the somewhat lighter oil previously used.

The account of this test together with the analysis of the lighter and heavier creosotes is given in a supplement to the report of Committee XVII, Proceedings, Vol. 19, pages 1061–1074. That report also includes a description of experiments made at the request of Mr. Courtenay, Chief Engineer of the Louisville & Nashville, to determine whether either with the lighter or heavier oil there was any filtering action which would cause the selective penetration of the lighter portions of the creosote to the interior of the ties.

Extraction of creosote from 1 inch layers, cut from a number of selected ties, showed that no measurable filtering action or selective absorption had taken place.

As regards penetrability of the two creosotes used in the plant tests at Guthrie, no measurable difference could be detected. With the same treating conditions 700 ties treated with the lighter oil resulted in an average absorption of 3.45 gal. per tie and with the heavier oil 3.39 gal. per tie.

For at least two years after this test, all of the creosote used by the Louisville & Nashville Railroad at both of its plants was similar to the heavy creosote shipped to Guthrie for the purpose of the above-mentioned experiments. As part of a general attempt to determine the character of service given by ties and timbers treated with heavy creosote, an inspection was made in January, 1931, of a number of 1918 red oak ties in the main line of the Louisville & Nashville between Lebanon Junction and Bards-

town Junction. In this inspection the writer was accompanied by R. M. Leeds, Division Roadmaster and Mr. Rainey, Supervisor.

The location of these ties had been established prior to our visit, therefore we were able to see somewhere between two and three hundred ties bearing 1918 dating nails and forty to fifty 1919 ties. The ties particularly noted were:

1918 red oak, northbound main line, near milepost 27 (borings 1, 2, 3 and 4 taken in this lot)
1918 red oak, southbound main line, near milepost 26 (boring No. 5 taken)
1919 pine, southbound main line, near milepost 24 (boring No. 6 taken)
1919 red oak, northbound main line, near milepost 22 (boring No. 7 taken)

The great majority of the 1918 red oak ties inspected were in excellent condition, both as to soundness and freedom from serious checking or plate cutting. Two or three ties showed slight decay on the face (probably heart face with slight treatment) and a few showed heart rot at ends, possibly infected before treatment. A small percentage of these 1918 red oaks were moderately to rather badly checked, but none indicated renewal.

Since these ties were installed, the rail has been changed from 90 to 100 lb., this heavier rail being put in during the period of 1922–1928. The track ballast has also been improved. The track inspected included tangential and curved sections and in general was considered to represent a good average of main line track on this Division.

In March, 1931, two ties were taken from this track by Roadmaster Leeds and sent to the Research Laboratory of the Barrett Company for examination. Sections were cut under the rail base and as shown in the accompanying photographs, there is no indication of decay around the spike holes or elsewhere.

Creosote from the two ties was extracted, according to the usual method.

Comparative Analysis of Creosote in Red Oak Ties—Treated in 1917
Before and After Thirteen Years' Service

	Original	*Extracted* (Combined from) (2 Ties)
Spec. gravity at 38°C.	1.097	1.138
Insoluble in benzol	0.97%	——
Distillation		
0—210°C.	0.0%	1.0%
0—235	8.7	2.8
0—270	26.2	7.6
0—315	38.5	19.5
0—355	53.8	40.8
Residue	45.7	59.2
Float at 70°C.	34 sec.	37 sec.
Sp. gr. 235–315°C.	1.028	1.044
Sp. gr. 315–355°C.	1.098	1.110
Coke test	28%	5.5%

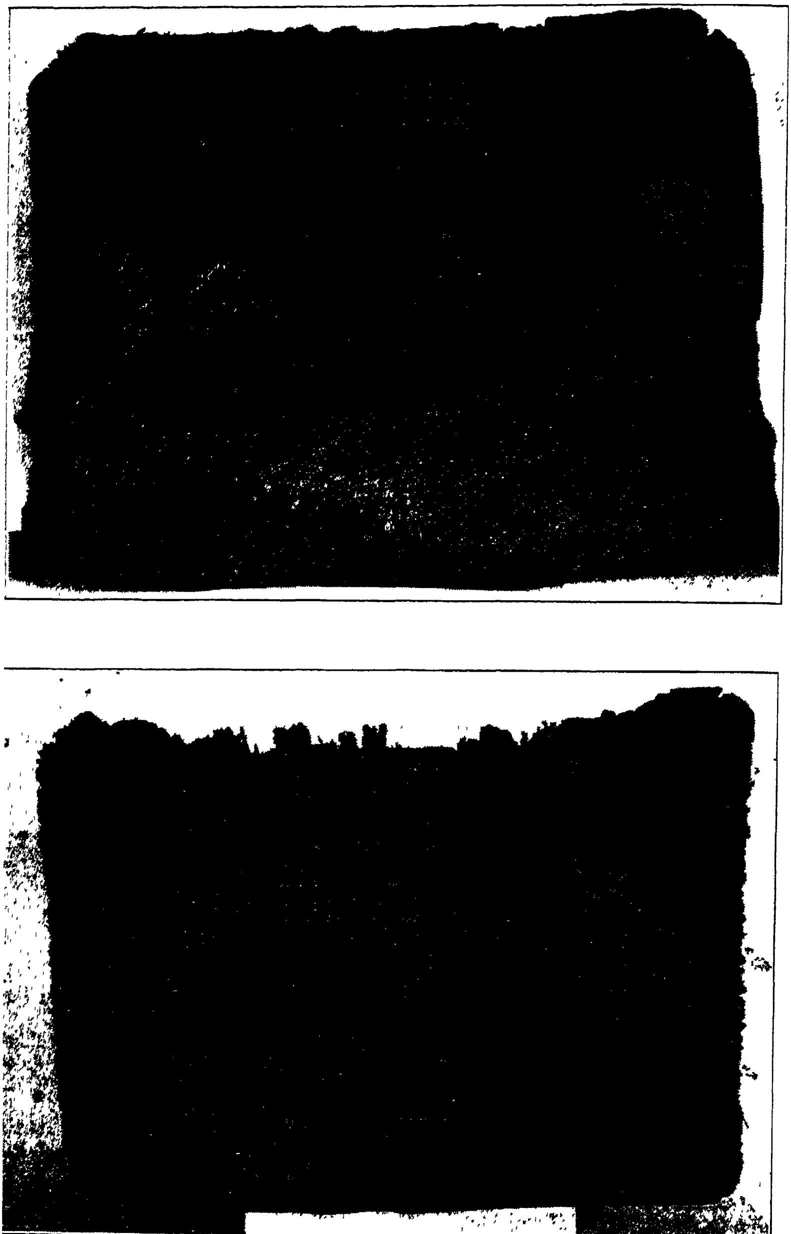
There can be no question that the creosote used in treating all 1918 ties on the Louisville & Nashville System was quite the same as shown in the above analysis.

The Barrett Company submitted their complete laboratory records for all shipments of creosote from 1918 to 1920. During 1918 shipments to Guthrie, all from Fairfield, Ala., totalled 500,000 gallons and all of this showed distillation residue at 355°C., in the range between 40 and 50 per cent.

Comparing the analysis of the original creosote and extracted creosote it is shown that of the portion of the original creosote distilling below 270 deg. 70 per cent has been lost during thirteen years of service.

Climatic conditions in the region covered by the railroad are certainly not unfavorable to decay. It is believed that based on renewals to date, the average life of the red oak ties treated with heavy creosote in 1918 will be well beyond twenty years.

The author acknowledges the very helpful co-operation on the part of representatives of the Louisville and Nashville Railroad without whose assistance this information could not have been obtained, and desires also to acknowledge their approval of making this report to Committee XVII of the A.R.E.A.



SECTIONS OF TWO TIES, CUT UNDER RAIL BASE. NOTE NO INDICATION OF DECAY AROUND SPIKE HOLES.

Appendix C

(3) PILING USED FOR MARINE CONSTRUCTION

W. G. Atwood, Chairman, Sub-Committee; G. B. Campbell, C. C. Cook, H. R. Condon, L. H. Harper, G. R. Hopkins, H. E. Horrocks, W. H. Kirkbride, A. J. Loom, G. C. Stephenson.

The Committee submits herewith its report on the present condition of the long-time test pieces in its charge, together with such other pertinent information as has been made available. The report is submitted as information.

1. Tropical Timber

ANGELIQUE *(Dicorynia, paraensis Benth).* All test pieces have been lost except at the Panama Canal Station which reports:

Balboa, C. Z. Submerged September 13, 1923. The sides do not appear to be in bad condition but teredo are present as well as the wood boring pholads, Martesia striata and xylophaga sp. (Fig. 1).

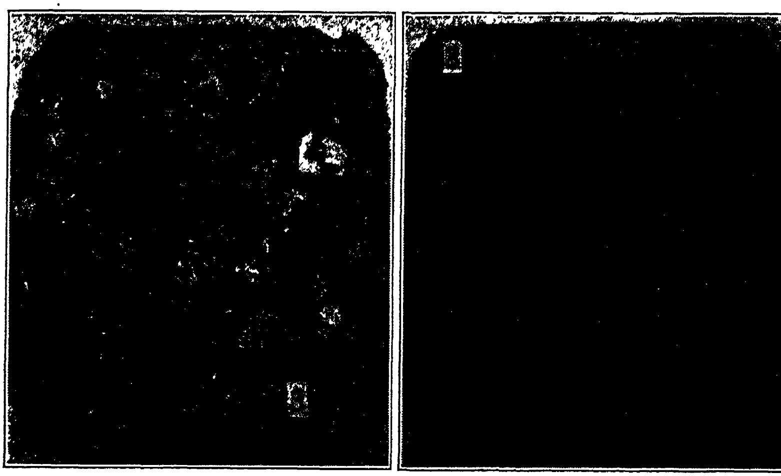


FIG. 1.

1612–3 Basralocus or Angelique, 8″ × 8″ × 24″, September 13, 1923 to August 18, 1931. Note especially the poor condition of the end, amount of shell and other growth. Cut surface is only 1½″ from this end and shows a remarkably sound condition at this level. Five small teredo holes can be seen and three cavities of Martesia. Upon dissection of this thin slab, 89 specimens of Martesia and 56 of Xylophaga were recovered, an almost unbelievable number. (Zetek photo)

MANBARKLAK *(Lecythis ollaria L).* Florida East Coast Ry., Key West, Fla. Submerged Aug. 5, 1923. Attacked by both limnoria and ship worms, though most of damage is on the surface. This block was originally 8″ × 8″ and is now 7″ × 7″ as a result of the limnoria attack.

Panama Canal, Balboa, C.Z. Submerged Sept. 13, 1923. Sides clean and not seriously attacked by limnoria. Teredo not numerous, animals small and confined closely to sides. Martesia present in small numbers.

GREENHEART *(Nectanda rodieoi, Schomt).* Panama Canal, Balboa, C.Z. When tapped with a hammer wood did not appear to be badly riddled. There was no exterior indication of any great change since last year. Teredo are present and alive on all sides and ends.

TURPENTINE WOOD *(Syncarpia Laurifolia)*. U. S. District Engineer, Charleston, S. C.

Submerged at Castle Pinckney, June 24, 1925. Slightly bored on surface and ends.

U. S. Naval Air Station, Pensacola, Fla.

Submerged July 19, 1924. Sapwood riddled by shipworms and Martesia but heart wood not attacked.

Panama Canal.

Balboa Heights, C.Z. Submerged Aug. 19, 1929. A few teredo and Martesia, in the sapwood only.

PANAMA CANAL

Through the courtesy of Col. Harry Burgess, Governor of the Panama Canal Zone, we are able to present the following report on the tests being carried on at Balboa:

"On August 18, 1931, James Zetek performed the annual inspection of timbers being tested against marine borers and has furnished the following report:

"Practically all timbers were covered with dense growth of marine life, such as sponges, hydroids, bryozoans, "worms", mollusk eggs, and many species of mollusks. Among the latter were noted three species of Crepidula (onyx, squama lessoni and aculeata), Crucibulum spinosum, Vermicularids, Anomia peruviana, masses of Pteria and several kinds of oysters and allied forms.

"The only timber that was practically free of all growth was native Alazano (Calycophyllum candidissima) whereas timbers close to it were heavily coated. Amarillo was not heavily covered.

"The following timbers were 'closed' at this time:

1622–23 Yellow Pine, Ac-Zol treatment
1630–32 Untreated Amarillo
1706–31 Yellow Pine, Bruce Tri-Treat treatment (Fig. 2)
1629–13 Nicaragua Pitch Pine, untreated

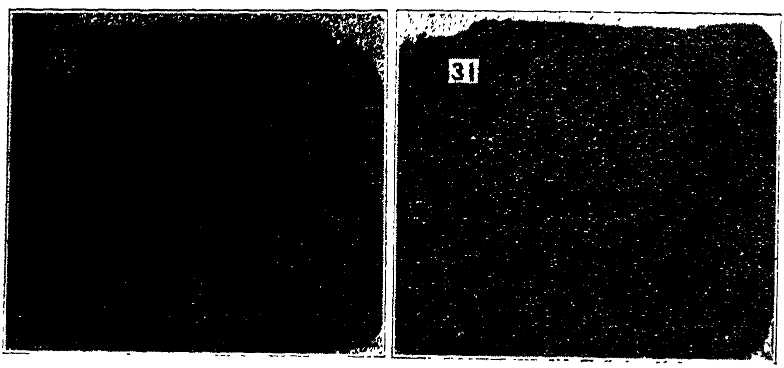


FIG. 2.

1706–31 Yellow Pine, Bruce Tri-Treat, 7″ × 9½″ × 30″, September 11, 1930 to July 18, 1931. End view and appearance of section cut 2″ from end. Note abundance of teredo burrows and also one in the heartwood. Only 1 Martesia striata was found, no Xylophaga. (Zetek photo)

"A supplementary report will be made later on the species of teredo involved. Last year I obtained two new species, and this year an additional one that may prove to be new to science. Neobankia zeteki and Neoteredo miraflora were present.

ANOURA (1609–2). *Conepia sp.* from Dutch Guiana, 8″ × 8″ × 24″, submerged Sept. 13, 1923. There is considerable surface destruction due to gribble, and much marine growth. It appears to be worse than greenheart. Many teredo holes on all sides and ends and pallets were seen protruding.

"Foengo (1608–4) *Parinarium campestre Aubl.* from Dutch Guiana, 8" × 8" × 24", submerged Sept. 13, 1923. There was considerable surface destruction, some of it due to gribble. The teredo picture does not appear to be serious and the shipworms appear to be confined close to the surfaces. Xylophaga sp. was present in few numbers.

"Sponse Hoedoe (1610–5) *Licania macrophylla Benth.*, from Dutch Guiana, 8" × 8" × 24", submerged Sept. 13, 1923. General appearance is good, teredo holes not plentiful. However, I found about 15 pholad openings on each side and took three specimens for record.

"Ingiebarki (1611–6) *Licania heteromorpha Benth.*, from Dutch Guiana, 6½" × 7" × 24", submerged Sept. 13, 1923. Sides and ends are riddled and badly eroded. The wood was hard and firm. Teredo burrows were confined close to the sides, and the ship-worms were all small. In this slab I found 9 specimens of Martesia striata and 8 of Xylophaga.

"Alazano (1627–8) *Calycophyllum Candidissimum (Vahl),* D.C. From Panama, all heartwood, 6" × 6" × 30", submerged October 17, 1929. The sides are clean of all marine growth and show no work of gribble. Teredos appear to be few, however, I counted about 20 pholad openings on each of four sides.

"Malabayabas (1606–9) *Tristania decorticata Merr.*, from Philippine Is., 12" × 12" × 13", submerged September 13, 1923. The wood appears to be in good condition with few teredos. Many Martesia are present.

"Kajol Lara (1615–11) *Metrosideros sp.*, from the Celebes, 6½" × 6½" × 30", submerged October 26, 1925. There are not many teredos present and these appear to be confined close to the surfaces. No evidence of pholads. Very little destruction due to gribble.

"Kajol Malas (1616–12) *Parastemon urophyllus,* from Sumatra, 6" × 6" × 30", submerged October 26, 1925. Some surface destruction due to gribble, much marine growth. Only few teredos appear to be present, confined close to the surfaces. No pholads seen.

"Nicaragua Pitch Pine (1629–13) *Pinus caribea Morelet,* from Nicaragua, 8" × 8" × 30", submerged March 12, 1930. Much surface destruction and large amount of marine growth. Thorough infestation by teredos in the section cut 2" from the end. In this slab were 1 Martesia and 3 Xylophaga. Experiment Closed.

"Alcornoque (1617–14) *Dimorphandra mora B. & H.* from Panama, all heartwood, 6" × 6" × 53", submerged November 22, 1927. Much marine growth adhering, but only few indications of teredo.

"Red Satinway (1624–21) from New South Wales, 6" × 6" × 24", submerged April 19, 1929. Much marine growth on all sides, but apparently very few teredos at work. There are many pholads present.

"Brush Box (1625–22) from New South Wales, 6" × 6" × 24", submerged April 19, 1929. Much marine growth. A slab 2½" thick was cut off of end. The latter shows numerous teredo holes close to sides and one cavity of Martesia striata. The wood was very hard and firm even to the edges.

"Yellow Pine Ac-Zol Treated (1622–23) U.S.A. 6" diam. × 30", submerged April 19, 1929. When hit with a hammer, the feel and sound indicated the interior to be well riddled. Much marine growth, also work of gribble. Upon dissection the timber was found to be thoroughly infested with teredos, even to the core. A few Martesia were found. Experiment Closed.

"Amarillo A.R.E.A. No. 1 Creosote (1630–30) *Chlorophora tinctorea,* 9¼" × 12½" × 9', submerged September 20, 1930. Very little marine growth, no signs of teredo or pholads.

"Yellow Pine Bruce Tri-Treat (1706–31) U.S.A. 7" × 9½" × 30", submerged September 11, 1930. When hit with a hammer, the feel and sound indicated considerable teredo penetration. See photo of end and of cut surface 2" from this same end. Note abundance of teredo burrows and one in the heartwood core. This core was about 3½" in diameter. The entire timber was dissected and found to be thoroughly infested, but only a few live teredos were found, rest all dead, only the pallets and valves present. There was much free creosote present. (Note.—The Bruce Chemical Corporation has dropped the term "tri-treat" and use in its place Preservative "A"). Experiment Closed. Fig. 2.

"AMARILLO untreated (1630–32). *Chlorophora tinctorea,* from Panama, 8" × 8" × 30", submerged October 4, 1930. When hit with a hammer the feel and sound indicated heavy teredo penetration. See photographs. The sides appear to be quite clean and free from trouble, but the cut section shows a large number of teredo burrows. A few Martesia and Xylophaga were present. The rest of the timber was like the cut section. Experiment CLOSED.

"OBSERVATIONS.—Next August sections will be cut from ends of all timbers excepting the one treated with creosote. It is of interest to note how well the Dutch Guiana timbers have withstood attacks, the tests now 8 years duration. It should be possible to use such resistant woods and to keep out the pholads and to keep the surfaces relatively free from marine growth, such timbers could, no doubt, be treated after having been cut to size."

"In the above report the identifying numbers of the specimens consist of two parts, namely, that before the dash indicating the Panama Canal Test Number, and that after the dash indicating the rack in which installed.

"It will be noted that three new test pieces were added between the 1930 and 1931 inspections, namely, Amarillo treated with creosote, Yellow Pine Tri-Treated, and untreated Amarillo. As stated in the first paragraph of this letter, seven pieces of treated white pine were added on August 25, 1931.

"The seven new pieces spoken of in the last paragraph are a new series treated by the Chemical Warfare Service at Edgewood Arsenal.

CHEMICAL WARFARE SERVICE SPECIMENS

SERIES No. 1

These test pieces were treated by the Chemical Warfare Service in their experimental cylinder at Edgewood Arsenal in 1924 and 1925.

No. 1A. 1 per cent of solution of ammoniacal copper carbonate.
No. 2. 1 per cent dyphenalamine chlorarsine in creosote.
No. 3. .75 per cent dyphenalamine chlorarsine and .5 per cent phenyldichorarsine in fuel oil.

Inspection reports are as follows:

New York, New Haven and Hartford Railroad.
Warren, R.I. Submerged May 1925. No change in condition since last year.

U.S. District Engineer, Charleston, S.C.
Two sets of specimens were submerged in June, 1925.

One No. 1 piece is slightly attacked on surface and ends and the other is practically destroyed.

Both No. 2 specimens are in good condition.

One No. 3 piece is lightly attacked on sides and ends and the other practically destroyed.

Florida East Coast Railway.
Key West, Fla. Submerged September 21, 1925. Control pieces attacked lightly and none of treated pieces attacked but they are all very soft and are disintegrating. This test will be closed out.

U.S. Naval Air Station, Pensacola, Fla.
Submerged June 25, 1925. One No. 1 piece is heavily attacked by shipworms and the other one slightly less.

Both No. 2 specimens are sound.

One No. 3 specimen heavily attacked and removed in 1930, and the other is heavily attacked by limnoria.

Bureau of Lighthouses, San Juan, P.R.
Submerged July 1, 1925. Two No. 1 pieces and one No. 2 remain at this station, one No. 2 having been lost and the No. 3 pieces having failed on account of limnoria attack. One No. 1 piece shows rather heavy limnoria attack and the other very little. The No. 2 piece shows no attack.

U.S. Navy Fleet Air Base, Coco Solo, C.Z.

One set submerged July 23, 1925, under concrete pier in front of Quarters "C". The control specimen was 90 per cent destroyed. No. 1 piece showed limnoria attack on about 45 per cent of its surface with a few teredo. Depth of attack about ¾". No. 2 specimen attacked to a depth of ½" on about 25 per cent of its surface. In the best condition of the three pieces No. 3 piece is heavily attacked by limnoria with some teredo, about 35 per cent of piece is destroyed.

Second set on center finger pier of Boathouse No. 24, Control specimen 95 per cent destroyed. No. 1 specimen showed limnoria and teredo attack on about 25 per cent of surface. No. 2 specimen showed slight limnoria and teredo attack on 5 per cent of surface but was in best condition of any. No. 3 specimen was heavily attacked by limnoria about 50 per cent being destroyed. (Fig. 3.)

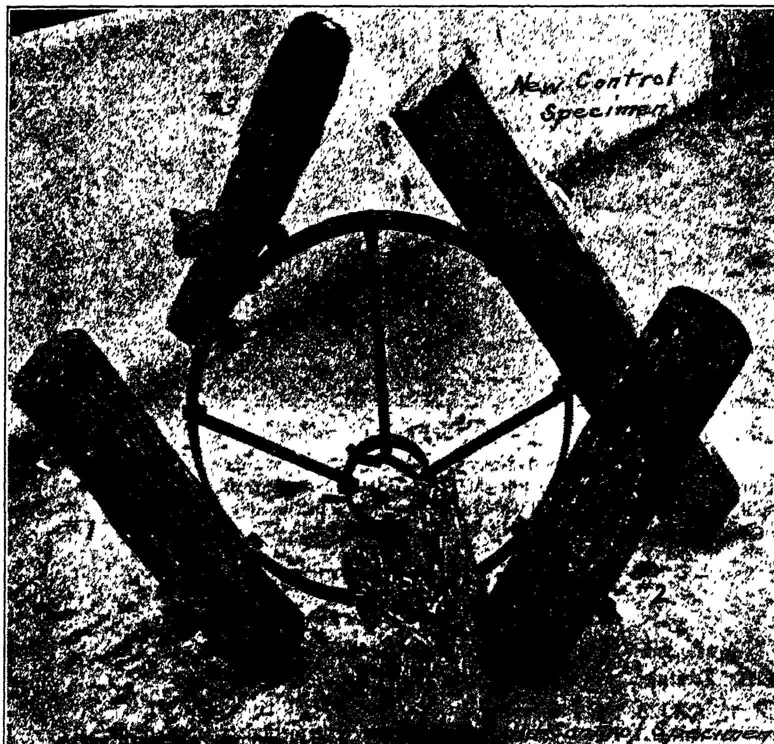


FIG. 3.
Set of chemical warfare service specimens at Coco Solo, C. Z.

Southern Pacific Co.

Submerged July 21, 1925 at Oakland Pier. Untreated control piece was heavily attacked. No. 1 piece showed a light limnoria attack over its entire surface. Nos. 2 and 3 pieces showed no attack.

Peralta St. Oakland moved from Port Costa. Submerged July 22, 1925. Nos. 1 and 3 show light limnoria attack and No. 2 no attack.

Puget Sound Navy Yard.

Pier 4, submerged October 14, 1925. Untreated control pieces riddled by Bankia after 1 year immersion (Fig. 4). No attack on No. 1 and very slight limnoria attack on Nos. 2 and 3.

Pier 8, submerged November 3, 1925. Untreated control piece heavily attacked by limnoria and destroyed by Bankia in one year. No attack evident on any of the treated pieces.

Pearl Harbor Naval Station, Pearl Harbor, H.I.
Report not received.

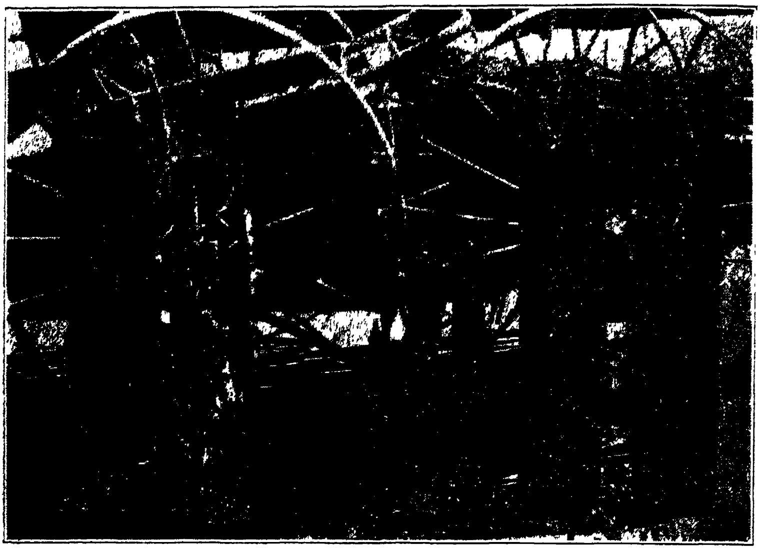


Fig. 4.

"716–31" Puget Sound Navy Yard, Bremerton, Washington, 8 September 1931. Pier 4. *Rack No. 1*—One untreated control piece on left submerged one year. Piece split open. *Rack No. 2*—Two untreated control pieces, one on right and one center, submerged one year. Piece split open.

CHEMICAL WARFARE SERVICE SPECIMENS

Series No. 2

A new series of test pieces was treated at the Edgewood Arsenal in the first half of 1931. Treatment was as follows:

1. A.R.E.A. No. 1 Creosote.
2. A.R.E.A. No. 1 Creosote with 0.71 per cent methylarsenious oxide.
3. A.R.E.A. No 1 Creosote with 0.77 per cent diphenylaminechlorarsine.
4. A.R.E.A. No. 1 Creosote with 2.5 per cent dinitrophenal.
5. Petroleum residuum with 2.5 per cent dinitrophenol.
6. Petroleum residuum with 0.84 per cent methylarsenious oxide.
7. Petroleum residuum with 0.87 per cent diphenylaminechorarsine.

Two sets of these specimens were shipped to each of the following test stations:

Fort Tilden, New York Harbor, installed September 29, 1931.
U. S. District Engineer, Charleston, S. C., installed September 19, 1931.
Naval Air Station, Pensacola, Fla., installed August 19, 1931.
Panama Canal, Balboa, C.Z., installed August 25, 1931.
Bureau of Lighthouses, San Juan, P.R., installed August 27, 1931.
Southern Pacific Co., San Francisco Bay, installed.
Puget Sound Navy Yard, Bremerton, Wash., installed.
Pearl Harbor Naval Sta., Pearl Harbor, H. I., installed.
Naval Station, Cavite, P.I., installed.

Copper Resinate Tests

These pieces were treated last year by a double impregnation process at Brunswick, Ga., by the patentee. Inspection reports follow:

U. S. District Engineer, Charleston, S. C.
Two test pieces submerged at Castle Pinckney July 7, 1930. Both pieces were in perfect condition one year later (Fig. 5).

Fig. 5.
Copper resinate test pieces, Castle Pinckney.

Naval Air Station, Pensacola, Fla.
Submerged summer of 1930. Untreated control piece heavily attacked and treated pieces have several well established colonies of limnoria on them, though no real structural damage has been done as yet.

Fleet Air Station, Coco Solo, C.Z.
Not reported.

Southern Pacific Company, Oakland, Calif.
Submerged August 12, 1930. Two pieces lost, light limnoria attack on remaining two.

Puget Sound Navy Yard.
Submerged September 1930. Test pieces not attacked.

Pearl Harbor Naval Station.
One piece intact. The other two show light limnoria attack.

Ac-Zol Tests

These tests have generally been abandoned because of the practical destruction of the test pieces by marine borers. They were submerged in the summer of 1928 after treatment with a 6 per cent solution of Ac-Zol. It would appear that in this concentration at least this material has little value as a protection against marine borers.

REPORT OF INSPECTION JULY 31, 1931, OF SPECIMENS FURNISHED THROUGH DR. HERMANN VON SCHRENK AND COL. WM. G. ATWOOD, AND INSTALLED IN SAN FRANCISCO BAY

(P = Pine F = Fir)

Barrett Manufacturing Company Material

Placed Station B, Pier 7, San Francisco, January, 1923, moved to Biological Station, Oakland Pier, % S.P. Co., December, 1925. No attack except slightly Limnoria.

Gate No.	*Specimen No.*	*Treatment*	*Condition July 31, 1931*
B–4	P 1	Coke oven original	P 1 No attack
	2	ditto solids removed	P 2, 3 and 4, slightly eroded by Limnoria on ends; sides slightly attacked near ends.
	3	ditto acids removed	
	4	ditto bases removed	No apparent increase since last year.
B–5	P 5	Coke, minus residue 360 deg. C.	P 5, 6 and 7, slightly eroded by Limnoria on ends. P 5 also on sides next to ends.
	6	Coke, minus fraction 239–270 deg. C.	
	7	Coke, minus fraction up to 230 deg. C.	No recent attack. P 8 somewhat greater, light attack on sides and ends.
	8	Coke, minus fraction 270–360 deg. C.	
B–6	P 9	Vertical retort original oil	P 9, P 10, 11 and 12. Light general Limnoria attack on ends and sides. Little change during last two years.
	10	ditto minus solids	
	11	ditto minus acids	
	12	ditto minus bases	
B–7	P13	ditto minus residue above 360 deg. C.	P13 a few light Limnoria burrows on ends.
	14	ditto minus fraction 230–270 deg. C.	P14 light attack of last year not now noticeable.
	15	ditto minus fraction up to 230 deg. C.	P15 no attack.
	16	ditto minus fraction 270–360 deg. C.	P16 very light Limnoria attack on ends.
B–8	F 1	Coke oven oils duplicating. B–4 in identical order.	F 1, 2, 3 and 4, all slightly eroded on ends. On sides, attack confined to line across specimens where gate had rubbed against a submerged brace. No apparent change since last year.
	2		
	3		
	4		

Gate No.	*Specimen No.*	*Treatment*	*Condition July 31, 1931*
B–9	F 5 6 7 8	Coke oven oils duplicating B–5 in identical order.	All slightly eroded on ends. Only trace on sides. P 7 and 8 very light Limnoria attack during year.
B–10	F 9 10 11 12	Vertical retort oils duplicating B–6 in identical order.	P 9, 10, 11 and 12 show light attack on ends and sides near ends. Very little change during last two years.
B–11	F13 14 15 16	Vertical retort oils duplicating B–7 in identical order.	F13 and 16. Considerable Limnoria attack but little change since last year. F14 and 15. Light Limnoria attack. With small change during last two years.

1931 REPORT ON TEST PILES

The following tables, 1–A to 1–D, give the 1931 condition of four sets of Test Piles driven in 1919 and 1920 at Seattle, Tiburon in San Francisco Bay, San Pedro and San Diego. Each set originally consisted of seven piles, including the following:

(3)	Old creosoted fir piles originally driven in 1890.	Table 1–A
(1)	Old creosoted fir pile originally driven in 1901.	Table 1–B
(2)	New freshly creosoted fir piles.	Table 1–C
(1)	New untreated fir pile.	Table 1–D

The untreated piles were destroyed in three or four years, as shown in Table 1–D, leaving six piles in each set.

The set at San Diego was exposed for test by the A.T. & S.F. Railway Company in their wharf No. 63, until this wharf was dismantled in 1925. After being repaired they were redriven by the Southern Pacific Company at Long Beach, California, and the test continued.

Table 1–A—Test Piles

CREOSOTED FIR PILES FROM SOUTHERN PACIFIC COMPANY OLD LONG WHARF, DOCK "A", OAKLAND. ORIGINALLY DRIVEN IN 1890. PULLED IN 1919 AND REDRIVEN ELSEWHERE. EXPOSED TO MARINE BORER ATTACK FORTY-ONE YEARS TO DATE

Mark	*Date*	*Railroad*	*Redriven for Test Location*	*1931 Inspection Remarks*	*Borers*
A–6	1920	N.P. Ry. Co.	Seattle	Free from Teredo.	....
A–8	1920	N.P. Ry. Co.	Seattle	Free from Teredo.	....
A–32	1920	N.P. Ry. Co.	Seattle	Free from Teredo.	....
A–19	1919	N.W.P.RR. Co.	Tiburon	*No attack, good condition.	....
A–28	1919	N.W.P.RR. Co.	Tiburon	*No attack, good condition.	....
A–29	1919	N.W.P.RR. Co.	Tiburon	*No attack, good condition.	....
A–5	1919	S.P. Co.	San Pedro	Slight limnoria attack in 1924 in 3 spots at edge of low water. Not now active.	Limnoria
A–20	1919	S.P. Co.	San Pedro	Slight limnoria attack at low water in 1924. Not now active.	Limnoria
A–34	1919	S.P. Co.	San Pedro	2 holes 3″ deep filled with asphaltic cement in 1927. Not active since.	Limnoria

Mark	Date	Railroad	Redriven for Test Location	1931 Inspection Remarks	Borers
A–2	1920	A.T. & S.F.	San Diego	Pulled in 1925.	....
A–2	1925	S.P. Co.	Long Beach	Holes attacked, repaired in 1925. No further attack to date.	Limnoria
A–7	1920	A.T. & S.F.	San Diego	Pulled in 1925.	
A–7	1925	S.P. Co.	Long Beach	Holes of borer attack repaired 1925. No further attack to date.	Limnoria
A–33	1920	A.T. & S.F.	San Diego	Pulled 1925.	
A–33	1925	S.P. Co.	Long Beach	Holes of borer attack. Repaired 1925. No further attack to date.	Limnoria

* San Francisco Bay.

Table 1–B—Test Piles

CREOSOTED FIR PILES FROM SOUTHERN PACIFIC COMPANY OLD LONG WHARF DOCK "E", OAKLAND. ORIGINALLY DRIVEN IN 1901. PULLED IN 1919 AND REDRIVEN ELSEWHERE. EXPOSED TO MARINE BORER ATTACK THIRTY YEARS TO DATE

Mark	Date	Railroad	Redriven for Test Location	1931 Inspection Remarks	Borers
E–46	1920	N.P.Ry. Co.	Seattle	Free from teredo.	
E–42	1919	N.W.P.Ry.	Tiburon	*2 holes attacked in 1926 1927 repaired. No further attack.	Limnoria
E–38	1919	S.P. Co.	San Pedro	Slight attack at low water ½" to ¾" deep. Do not appear active at present.	Limnoria
E–50	1920	A.T. & S.F.	San Diego	Pulled in 1925.	
E–50	1925	S.P. Co.	Long Beach	Light attacks in 1927 repaired. No further attack.	Limnoria

* San Francisco Bay.

Test Piles—Table 1–C

FRESHLY CREOSOTED FIR PILES EXPOSED TO MARINE BORER ATTACK ELEVEN YEARS TO DATE

Mark	Date	Railroad	Redriven for Test Location	1931 Inspection Remarks	Borers
47	1920	N.P. Ry. Co.	Seattle	No attack to date.	....
48	1920	N.P. Ry. Co.	Seattle	Old sign in check and knot near bottom. No live teredos now.	Teredo
43	1919	N.W.P.R.R.	Tiburon	*No attack to date.	....
44	1919	N.W.P.R.R.	Tiburon	*No attack to date.	....
40	1919	S.P. Co.	San Pedro	*No attack to date.	
41	1919	S.P. Co.	San Pedro	*No attack to date.	
51	1920	A.T. & S.F. Co.	San Diego	Pulled in 1925.	
51	1925	S.P. Co.	Long Beach	Holes of 1925 repaired. No further attack to date.	Limnoria
52	1920	A.T. & S.F. Co.	San Diego	Pulled in 1925.	
52	1925	S.P. Co.	Long Beach	Holes of attack in 1925 repaired. No further attack to date.	Limnoria

* San Francisco Bay.

TABLE 1–D

UNTREATED FIR PILES, EXPOSED TO MARINE BORER ATTACK

Mark	*Date*	*Railroad*	*Driven for Test Location*	*1931 Inspection Remarks*	*Borers*
49	1920	N.P. Ry. Co.	Seattle	Broken off at mud line 1923.	Limnoria Bankia
45	1919	N.W.P. RR. Co.	Tiburon	*Broken off at mud line.	Limnoria Bankia Teredo Navalis
39	1920	A.T. & S. F. Ry.	San Diego	Broken off at mud line 1923.	Limnoria Probably Bankia

* San Francisco Bay.

Summary

Among the tropical timbers, turpentine wood still seems to be of great value, but several of the South American timbers being tested at Balboa show very fair results. Those containing finely divided silica seem to resist the teredine borers, but are attacked by limnoria to some extent.

Chemical Warfare specimens of Series I show that all of them have resistance to attack, but the No. 3 treatment seems rather attractive to limnoria. The No. 2 specimens are still most of them free from attack but this may be as much the result of the use of creosote as a carrier as the effect of the toxic.

The first year's reports on copper resinate do not give much encouragement so far as resistance to limnoria is concerned, though later results may be better.

The San Francisco Bay tests, now 8 years old, still fail to give any indication as to the relative value of the different creosotes, because in spite of the destruction of many untreated control pieces, there is no significant attack on the treated pieces.

Conclusion

This report is submitted as information. It is recommended that the subject be continued.

Appendix D

(5) DESTRUCTION BY TERMITE AND POSSIBLE WAYS OF PREVENTION

Dr. Hermann von Schrenk, Chairman, Sub-Committee; W. G. Atwood, C. C. Cook, L. H. Harper, G. R. Hopkins, F. D. Mattos, L. B. Shipley, W. A. Summerhays, C. M. Taylor, C. S. Wiltsee, Jr.

Your Committee has continued its investigation with reference to termite destruction and protection. Most interesting information has been received during the year, all of which indicates continued serious attacks by these insects. Many architects and engineers apparently do not appreciate the necessity for considering possible termite attack when designing and constructing new buildings, particularly in regions indicated on the map printed in our first report (Proc. A.R.E.A., 31: 727; 1930). Again we wish to emphasize the fact, that where proper precautions are taken at the time

the building is constructed (and this refers not only to buildings but to all kinds of structures where wood is involved) termites can be absolutely stopped. This statement refers of course only to the subterranean termites. Protective measures for dry wood termites are still in the process of preparation.

As a result of the continued activities of these insects, a number of individuals and companies have started operations in various parts of the United States to repair termite infested buildings. A good many appeals have been made to the Bureau of Entomology of the U.S. Department of Agriculture with respect to the reliability of such companies and the methods and chemicals which they use. As a result of these inquiries, the U.S. Department of Agriculture issued a Press Information Circular, dated August 11th, 1931. This circular is of such significance generally, that your Committee presents same in full herewith:

SCIENTISTS WARN HOME OWNERS OF "TERMITE TREATMENT" FRAUDS

Home owners should beware of overdrawn and alarming reports of injury to building by termites or white ants, says the U.S. Department of Agriculture. In particular they should be wary when exaggerated statements of this kind form a part of the "sales talk" for a "termite treatment." Many of these treatments are expensive and are not correspondingly effective. Reports to the Bureau of Entomology indicate that sharpers, overemphasizing the real injury that termites are likely to do, are filching from home owners hundreds of thousands of dollars and rendering little or no effective service in return.

State officials and others reporting to the Bureau of Entomology reveal that the termite treatment sharpers are particularly active in the South and in some of the Far Western States. In these areas many cities have in recent years amended their building codes as advocated by the Bureau of Entomology and now require adequate safeguards against termites in new construction.

Salesmen, however, have been exaggerating the danger from termites in an effort to sell treatments, many of which have little or no merit, but which they picture as absolutely necessary to prevent the collapse within a short time of buildings invaded or under alleged danger of being invaded by the termites.

The Bureau of Entomology says that there has been no change in the situation in the South and West as to termite damage; that conditions are substantially the same now as they have been for the last 50 or 100 years. The records indicate that the collapse of a building on account of termite damage is so rare as to be for practical purposes a negligible risk. It is true that where termites have been in buildings for many years—as indicated by emerging swarms of the winged forms—the foundation timbers, and even the floors and adjacent woodwork, may have become so weakened as to make necessary some replacement.

The entomologists point out that an experience of 35 years in termite control indicates that radical reconstruction of the foundations is the only permanent and effective remedy for buildings which, because of original faulty construction, have become heavily infested. Such remedial measures as spraying or fumigation, or even removal of the worst infested timbers, without other protection, are at best temporary. Spraying and fumigation are practically useless.

One of the popular remedies being exploited is the spraying of woodwork with poisons. Spraying of construction timbers or other woodwork, even under a forced stream, is of no real value. The poison has little if any penetration unless the timbers are so badly eaten and rotted that they soak up the mixture like a sponge—in which case they are useless and should be replaced.

Another exploited remedy is the poisoning of soil near the foundation walls or supporting pillars underneath the buildings. All that can be said now of such treatment is that it is still very much in the experimental stage. On present information the Federal entomologists can not recommend it as a permanent remedy.

The only effective remedy for termite damage is to provide termite-proof materials for foundations. This can be done in two ways:

(1) Reconstruct the foundation walls, including cellar and cellar floors, of concrete and stone, using standard mortar; thoroughly fill all openings in masonry

or tile construction; and use, where necessary, mechanical barriers, such as metal termite shields. With this protection against entry, movable woodwork placed in such basements and the woodwork of the main and upper floors can be fully and adequately protected from termite damage.

(2) Where in the construction of buildings it is desirable or necessary to use wood touching the ground or near it, this wood and all foundation timbers should be impregnated in an approved manner by one of the standard chemical wood preservatives.

These are the essentials of termite proofing in new construction. In their own interest, house owners are cautioned not to accept any new or easy methods, such as fumigation or spraying of woodwork in place, or soil poisoning, for the control or elimination of termites, until they have assured themselves of the effectiveness of the method by asking advice either from their own State Departments of Agriculture or other competent State authorities, or from the Bureau of Entomology in Washington.

Your Committee also advises that a number of experiments have been started by the United States Bureau of Entomology and by the Chairman of this Sub-Committee, to test a large number of so-called "soil poisons". It has been claimed that the activities of the ground termites can be prevented or stopped by applying various chemical compounds to the soil in the immediate neighborhood of the building or structure. There is no knowledge at the present time as to whether this method of operation can be counted on. Your Committee will advise details of these experiments in a subsequent report.

Conclusion

It is recommended that this report be accepted as information and the subject continued.

Appendix E

(7) LOSS OF PRESERVATIVE IN TREATED TIES IN TRACK DUE TO REPEATED USE OF OIL BURNING WEED DESTROYERS

C. S. Burt, Chairman, Sub-Committee; G. B. Campbell, H. R. Duncan, W. R. Goodwin, L. B. Holt, R. S. Hubley, A. J. Loom, W. T. MacCart, L. J. Reiser, T. H. Strate.

During 1929 your Committee conducted experiments in connection with this study and the results of such tests are published in full in the Proceedings for 1930, pages 751 to 757 inclusive. Similar tests conducted during 1930 and 1931 by several roads represented on the Committee are briefly described as follows:

Pieces 2″ × 8″ — 8′ were cut from 6″ × 8″ — 8′ thoroughly air seasoned White Oak, Red Oak, Hard Maple, Beech, Sycamore and Southern Yellow Pine ties. One piece was cut from the face side of each tie and the heart center eliminated. These were treated with A.R.E.A. grade 1 distillate oil, 80–20 mixture of grade 1 creosote and coal-tar, and 45–55 mixture of grade 1 creosote and California crude-oil, by the Lowry and Rueping processes, with final retention of preservatives varying from 3 to 10 lb. per cubic foot of wood. Retention of preservatives was determined by careful weighings of each piece before and after treatment. One piece from each tie was placed in track and subjected to operation of weed burning machines whereas the mate to each such piece was placed in adjoining track not to be affected by the weed burner. Those pieces that were not subjected to operations of the machine served as a means to determine natural changes occurring during the course of the experiment, such as change in moisture content and loss of oil by evaporation. All test pieces were carefully weighed before each operation, reweighed immediately afterward and calculations recorded.

The Committee felt that the same test pieces should be used during at least two successive weed burning seasons with view of determining difference in loss of preservatives between the first and subsequent burnings. Accordingly, some of the test pieces referred to above were subjected to operation of the weed destroying machines during 1930 and 1931, while others had been treatd only 30 and 60 days prior to time of 1931 experiments.

The loss in weight due to the effect of such machines as developed by these tests is shown by groups in the accompanying table, together with analysis of preservatives used in treatment of the experimental pieces.

					LOSS IN WEIGHT—Per Stick					
					1st Burning Aug. 11, 1930		2nd Burning July 27, 1931		3rd Burning Sept. 2, 1931	
Kind of Wood	Kind of Treatment	Kind of Preservative	No. Pcs.	Absorp. per piece	Burned	Not Burned	Burned	Not Burned	Burned	Not Burned
Pine	Rueping	Dist. Creosote	11	8.13#	.174%	.168%	2.30%	2.98%	.321%	1.45%
Pine	Rueping	80–20 Creo. coal tar	11	6.10#	.252%	.198%	2.72%	3.34%	.294%	1.38%
Red Oak	Rueping	Dist. Creosote	6	7.07#	.089%	.558%	1.31%	1.81%	.295%	.420%
Red Oak	Rueping	80–20 Creo. coal tar	6	7.59#	.081%	.480%	1.32%	3.16%	.213%	.787%
Beech & Sycamore	Rueping	Dist. Creosote	10	8.50#	.099%	.....	1.88%	.....	.098%	.....
Beech & Sycamore	Rueping	80–20 Creo. coal tar	9	9.60#	.086%	.....	2.25%	.....	.000%	.....
White Oak	Rueping	Dist. Creosote	6	3.83#	.000%	.115%	1.38%	3.05%	.000%	.582%
White Oak	Rueping	80–20 Creo. coal tar	6	5.50#	.092%	.255%	1.30%	2.80%	.000%	.446%
Pine	Rueping	Dist. Creosote	30	9.58#	(These ties (treated 6/6/31)		3.08%	3.13%	.950%	1.29%
Hard Maple	Lowry	45–55 Creo. crude oil	40	7.25#	(These ties treated May 20th.) (1931—burned Aug. 17, 1931)				.439%	.423%

ANALYSIS OF PRESERVATIVES USED IN ABOVE TESTS

A.R.E.A. Grade 1—Distillate Oil
Up to 210° C ... 2.80%
Up to 235° C ... 14.30
Up to 315° C ... 35.20
Up to 355° C ... 20.00
Residue (Soft) .. 27.50
Spec. Gravity ... 1.065 @ 38°
Water—Trace

80–20 Mixture Grade 1—Creosote Oil and Coal Tar
Up to 210° C ... 3.50%
Up to 235° C ... 7.20
Up to 315° C ... 33.40
Up to 355° C ... 17.70
Residue (Soft) .. 38.00
Spec. Gravity ... 1.093 @ 38°
Water—Trace

A.R.E.A. No 1—Domestic Creosote & Calif. Crude Oil
Up to 210° C .. 0.1%
Up to 235° C ... 2.9
Up to 270° C .. 3.8
Up to 315° C ... 15.0
Up to 355° C ... 16.9
Residue (soft paste) 61.1
Spec. Gravity ... 1.003 @ 38°
Water—Trace

These figures show a very slight difference in the loss by weight from pieces subjected to the machines as compared to loss from those not burned, and the actual loss of preservatives so small that it may be considered an almost negligible amount. It is observed that the effect of weed destroying machines on treated ties, as regards to loss of preservative, diminishes almost directly in proportion as the age of the tie increases. This is particularly applicable to ties of the hardwood group.

Ties that have been in service more than three years are rarely affected unless they are mechanically worn or damaged by derailments. Old ties that are so damaged and worn are more often affected by the second burning because the flame is also communicated to the ties from dead burning grass and vegetation. Speed at which machines are operated is governed by the kind and growth of vegetation but at average operating speed the ties are subjected to the heat not more than 1½ seconds. Untreated ties ignite much more readily than creosoted ties and burn freely—particularly so if they show any splintering from any cause, or if decay has developed. Burning of such ties may be considered beneficial rather than detrimental as the surface chars and destroys

incipient fungus growth. Machines should not be allowed to stand in one place immediately after the flame has been shut off as the heat radiating from the apron will damage the ties beneath. It is of particular importance that machines be operated at the specified speed—observation develops that often the rate of travel is lower than the speed required to meet conditions, thereby increasing the possibility of damage to ties.

The kind of ballast and track dressing has much to do with the effect of these machines on ties—needless to say the effect is lessened according to the protection provided by the ballast. In making this study it has not been overlooked that much of the failure of treated ties today is due to mechanical wear—such failure occurs directly under the rail and this section is subjected to less heat than any other part of the tie because of protection provided by the rail base and tie plate.

Conclusions

Further investigation is anticipated but the results of the experiments described above further indicate that little actual loss of preservative may be expected from normal operation of weed burning machines, whereas considerable damage to treated ties may occur from careless operation of such machines. It is therefore urged that the work of these machines be very closely supervised by all concerned.

It is recommended that this report be accepted as information and the subject continued.

Appendix F

(6) INCISING OF FOREST PRODUCTS MATERIAL

H. R. Duncan, Chairman, Sub-Committee; R. S. Belcher, C. S. Burt, H. R. Condon, C. C. Cock, L. H. Harper, M. F. Jaeger, A. J. Loom, J. H. Reeder, O. C. Steinmayer, C. S. Wiltsee, Jr.

In considering this subject, your Committee has very carefully studied the work that has already been done by others interested. Investigation of this subject was started by the Forest Products Laboratories of Canada under their Project No. 80 of February, 1929. Their investigation was made on the following:

(a) Material incised before air seasoning.
(b) Material incised after air seasoning.

In carrying on their work, they used the following species of wood: birch, beech and maple.

The specific object of their investigation was—

1. To study whether incising of hardwood before air-seasoning
   (a) Accelerates air-seasoning.
   (b) Increases absorption and penetration of creosote.
   (c) Reduces checking during air-seasoning.

The ties selected for this experimental work were produced at Perras and Farm Point, Que., and shipped to the Delson, Quebec, treating plant of the Canada Creosoting Company, where the air-seasoning, incising and treating were carried out.

Treatment

The ties were treated in one charge with an average absorption of 6.84 lb. of 70/30 creosote-coal tar mixture per cubic foot.

A

Penetration

The penetration in the ties examined was measured by 7 borings on the top and bottom faces, total 14 borings per tie.

This matter is reported under Progress Report No. 1, Project 80, dated March, 1930, by the Forest Products Laboratories of Canada.

Their conclusions are as follows:

(1) Incising before air-seasoning had no appreciable effect on the rate of air-seasoning or the moisture content after air-seasoning.

(2) Incising before air-seasoning did not increase the absorption or penetration of the treating mixture.

(3) Incising before air-seasoning slightly reduced checking in ties air-seasoned four to five months as compared with matched ties incised after air-seasoning and indications are that the reduction in checking would be more noticeable when ties are held in the seasoning yard for a longer period.

For a three-year period, all ties manufactured by the Somers Lumber Co. for the Great Northern at Somers, Mont., were incised at the time they were manufactured. While it was the opinion that the incising assisted in speeding up the seasoning of the ties and also retarded checking to a considerable extent during the seasoning period, especially if the seasoning period was a long one, nevertheless they did not feel that the results justified the expense of this pre-incising. However, their plan was to reincise the ties as they were put through the boring and adzing plant after they had been seasoned and just prior to treatment. This incising after seasoning was done to insure better absorption and more uniform and greater penetration. This method is in effect at the present time. Species involved were the inter-mountain fir and larch.

During 1926, the Northern Pacific incised one carload of green hardwood ties at Paradise. These were birch, oak and maple ties which had been shipped from Brainerd, Minn. An equal number of ties were stacked in the yard at the same time without incising. After eight months of seasoning period during the spring and summer months, they were unable to determine that there were any less large checks in the incised ties than in those not incised.

The Santa Fe made a similar test in 1922 on 100,000 pieces of 7 × 8″ — 8′ Douglas fir ties incised on the West Coast and then stored at the Albuquerque Treating Plant. They were unable to determine that this method of handling was beneficial in any way.

During the Summer of 1931, the Santa Fe incised before storing in their yard approximately 5,000 green Pacific Coast Douglas fir ties 7 × 8″ — 8′ and placed them in their yard at National City, which are to be compared with unincised ties of the same kind during the seasoning period. They have also adzed, bored for spikes, grooved for tie plate ribs and incised approximately 5,000 green Douglas fir ties in the same yard for the comparison of such ties with similar ties on which all this work is done after seasoning.

During the fall of 1930, the Soo Line incised, bored and adzed a carload of Northern hardwood ties before storing them in yard at Minneapolis for seasoning.

In 1929 the Canadian Pacific Railway incised approximately 70,000 beech, birch and maple ties before seasoning with the thought in mind of eliminating the heavy checking which occurs in these Canadian hardwoods. They were so well pleased with the results obtained that the following year they incised before seasoning approximately one-half million hardwood ties of the same species. Since that time, they have continued the practice of incising before seasoning.

On May 28, 1931, seven members of your Committee and twelve associates interested in this subject visited the Delson treating plant of the Canada Creosoting Company

and made comparisons between several hundred thousand ties, about one-half of which were not incised and the other half of which had been incised before air-seasoning. At the time this inspection was being made and subsequently, discussion on the subject developed that there was considerable difference of opinion as to whether or not the results secured justified any expense to pre-incise these ties. It is, therefore, the opinion of your Committee that this subject should be investigated further, giving special attention to other species of wood than those which were considered by the Canadian Forest Products Laboratories. We propose the following, which can be elaborated on if it should be desirable after the work progresses:

1. Determine whether incising prior to seasoning—

   (a) Accelerates air seasoning.
   (b) Reduces checking and splitting prior to treatment and after treatment.
   (c) Obtains more uniform distribution and increases the penetration and absorption of preservatives.
   (d) Increases gross and/or net absorption of preservative.
   (e) Reduces time of treatment.

Determination to be made on cross, switch and bridge ties of mixed oak, southern yellow pine and mixed hardwoods if practicable. Sawn ties to be selected for tests. Following procedure to be followed:

(1) A substantial number of ties of like size, species of wood, place of production, time of logging, manufacture and shipment to be selected upon arrival at treating plant. Quantity to be not less than 1,000 cross-ties or 40,000 board feet of switch or bridge ties. Half the quantity to be weighed, incised and stacked in accordance with standard yard practice at plant involved. Half to be weighed and stacked in similar manner and immediately adjacent to other lot. Ten per cent of each lot of ties to be weighed at intervals of 60 days. Ties to be so weighed will be marked at time of stacking and will be located at representative points in the upper, middle and lower thirds of height of each stack. Relative positions of selected ties in incised and non-incised stacks will be the same. Bearing pieces to be stacked on edge to permit of easy removal and replacement of sample ties.

When incised lot is determined to be ready for treatment under procedure normally followed at the plant involved, one-half of the incised ties and one-half of the non-incised ties (divided vertically in stacks) will be weighed, examined for checks and splits, and average moisture content determined, and treated with usual cycles. Treating cycles and operations will be maintained as nearly constant as possible on incised and non-incised ties. Records will be kept of time, degree, and duration of air and oil pressures, temperatures and vacuum; gross and final retentions. Net retentions to be checked by weighing. Penetrations to be determined by borings.

When the remaining half of non-incised ties are determined to be sufficiently seasoned for treatment, they, together with remaining incised ties will be weighed, examined and treated as above, with the recording of similar data.

Prior to treatment of both lots, careful examinations will be made of extent of checking and typical photographs taken. Checks to be classified as large, medium and small. Cores taken after treatment to be accurately measured for determination of penetration. Incised and non-incised ties can be placed in test track to determine the effect of incising, with respect to splitting, after treatment and insertion in track.

Data obtained as above outlined should permit of deductions applicable to routine plant practice. It will not yield information of "laboratory" accuracy. It is believed, however, that information applicable to ordinary plant procedure should be the prime

object of the initial work, and that preliminary data which can serve as the basis for future research should be obtained at a reasonable expense.

Mr. Condon, a member of your Committee, who is Vice-President of the Century Wood Preserving Company, has proposed that this investigation be carried on at the Century Wood Preserving Company's plant at Newport, Delaware, in collaboration with Mr. Krell, Forester of the Pennsylvania. This will be at a location where it can be observed by many railroads, who are very much interested in the use of oak and hardwood ties.

Conclusion

It is recommended that this report be accepted as information and the subject continued.

Appendix G

(7) EXTENT, IF ANY, TO WHICH DECAY IS PERMISSIBLE IN TIES FOR TREATMENT, THE VARIOUS FORMS OF DECAY, AND THE METHODS OF DETECTING INFECTION AND DECAY

C. M. Taylor, Chairman, Sub-Committee; Wm. G. Atwood, Walter Buehler, H. R. Condon, E. B. Fulks, G. R. Hopkins, M. F. Jaeger, W. H. Kirkbride, W. T. MacCart, Clyde Osborne, J. H. Reeder, W. A. Summerhays.

This subject is one that has been discussed pro and con by users of ties, particularly since the preservative treatment thereof has become so universal. Its application is divided into two parts—namely, first the condition of any tie at the time of purchase and secondly the condition of any tie at the time of proposed preservative treatment.

The present tie specifications read as follows: "Decay," Section 12. The following decay will be allowed: In cedar and in cypress, "Pipe or stump rot" and "Speck", up to the limitations as to holes; in chestnut, "bark disease" up to ¼ inch deep. "Blue Stain" is not decay and is permissible in any wood.

The limitations specifically referred to in the standard specifications cover those ties which usually are not treated. As the great majority of all ties used by railroads today are those which are given some preservative treatment, it is therefore obvious that in any deviation from the standard specifications which say that all ties shall be "free" from "decay", consideration should be given to those species which constitute the largest percentages of ties which are given preservative treatment, such as oak, pine, gum, beech, birch, maple, elm, Douglas fir, hemlock and Jack pine.

The difficulties incident to the interpretation by inspectors to any deviation from the requirement of "decay" free ties is obvious. Furthermore, practical experience with inspection according to the present specifications as now interpreted by some tie inspectors develop the fact that even now some of them are prone to be too lenient in their interpretations. Furthermore, some ties have hidden defects which cannot be detected even under the most rigid inspection.

The fact that wood preservatives are able to lengthen the life of ties from an average of seven years to twenty or more, has created in the minds of some the thought that the preservative treatment might in some way or other, bring strength and durability to the defective portion of the ties. It is well to disclaim any such ability on the part of the preservative, and its function can be relied upon only to lengthen the life of sound wood only.

To suggest that the railroads accept ties with any defect is likely to upset the fine record which preservative treatment has set. When untreated ties were the rule rather than the exception, the presence of small defects did not have much effect on ties with an average life of seven to eight years. However, since the advent of treated ties with normal life histories of twenty to forty years, depending upon their mechanical ability to withstand track conditions, the presence of even a very small defect is likely to weaken the tie in due course of time, thereby limiting the possibility of a long life as should be expected from a treated sound tie.

As for the policy to be followed by the wood preserving plant, at the time ties are seasoned and fit for treatment, railroads have varying policies. In most cases, the ties are the property of the railroads and there is a tendency to consider them worthy of treatment, if showing slight defects, regardless of the attitude at the time of purchase. This practice is certainly most inconsistent and should be eliminated. Climate and weather conditions at various plants are such that oftentimes ties become fit for treatment in greater number than the particular plants are capable of treating, with the result that before all the ties are finally treated, some of them become "over-ripe"—a term used to designate those ties which have become over-seasoned and may not show any outward sign of decay. Unfortunately, under such conditions, many ties are treated which undoubtedly will not hold up mechanically. Furthermore, it is almost axiomatic to say that ties, which actually do show outside signs of decay, are really quite seriously deteriorated in strength, though they appear sound.

"Blue Stain" as referred to in the standard specifications is not decay and ties infected with this fungus organism alone can be classified as sound ties. The point to be remembered is that "blue stain" comes as a result of the presence of particular non-wood-destroying organism, and unless the ties are handled promptly, and stored properly to allow proper seasoning, the conditions under which "blue stain" is developed may lead to infection with wood-destroying fungi.

Molds are often another cause of rejection, particularly in connection with gum and beech ties. Here again the early stages of these molds need not be discriminated against, but their presence should be the basis for intelligent inspection, because ties harboring molds may at the same time also be infected with other organisms destructive to wood fibre.

Closely allied with "blue stain" and molds are the stains which may appear on wood adjoining a locality of active decay in the log from which the tie was manufactured. These stains, caused by fluids incident to the growth of fungi and which percolate outward from the point of active decay, are the advance indications of the stage where wood fibre is destroyed. Wood so stained is not always decayed, but the presence of any such discoloration of the wood should attract the attention of the inspector who should closely examine the tie, for the presence of actual decay.

A few years ago, under a cooperative effort, the American Wood Preservers Association, in cooperation with the United States Forest Products Laboratory, issued a booklet entitled "The Decay of Ties in Storage," written by Dr. C. J. Humphrey, Pathologist. This booklet was prepared to help persons engaged in inspecting cross-ties, to identify the various species of molds, stains and wood-destroying fungi. It contains plates showing the different fungi in colors as they appear in nature. The Sub-Committee believes that this book should be in the hands of every person identified in any way with the inspection of cross-ties. It defines very clearly those fungi which are to be discriminated against, as well as those which are classified as not being harmful.

To convince operating officials that they had better burn defective ties rather than treat them is oftentimes a very difficult matter; yet, it is a fact that ties have been

treated which cost the railroad more money than they would have cost had they burned the ties. This was due to the fact that ties broke down mechanically very soon after installation and had to be removed from the track inside of three or four years. The cost of treatment and cost of installation and removal was more than the cost of the untreated ties.

One very successful method for determining the actual condition of cross-ties at the time of treatment is that followed on several railroads, whereunder a small section is cut off the two ends of the tie, as the first function in the operation of adzing and boring of ties. Of course, this operation cannot be carried on safely with ties in which anti-splitting devices have been installed. The species which are most subject to decay are yellow pine and the TC group. In order that these ties may undergo the rigid inspection, several railroads do not apply any anti-splitting devices to certain species until after the ties have been through the adzing and boring operation. This practice is not standard, however, as some railways consider the application of the anti-splitting devices much more essential.

This expose of new end sections of ties is the very best way yet devised to give almost positive insight as to the condition of a tie. The expense incident to the operation is very small and the machinery necessary for it is easily added to the standard adzing and boring machine. In practice, it has been very definitely shown that many ties which would have passed the keenest sort of visual inspection, would after having the ends sawed off give positive indication of decay, sufficient to warrant the ties being classed as unsound.

Some railways have a system of marking defective ties that are treated and instructions are issued designating the placement of such ties in tracks that is used for storage purposes, or where little traffic is moved. The difficulty of such a policy is that sooner or later some of these defective ties are used in emergency work in renewing the main line traffic and eventually some of these fail in a few years and the blame is usually placed on the treatment, whereas the failure was purely mechanical.

From a standardization viewpoint, it is our recommendation that there be no change in the standard specification for the purchase of ties in so far as freedom from decay defects is concerned, and, secondly, we cannot develop any standard where it might be made possible for a railroad to change its instructions to the operators of any wood preserving plant whereunder ties exhibiting any decay could be considered satisfactory for preservative treatment.

Conclusion

This report is submitted as information and with the request that the Committee be discharged from any further consideration of the subject.

REPORT OF COMMITTEE IV—RAIL

EARL STIMSON, *Chairman;*	A. F. BLAESS, *Vice-Chairman;*
LEM ADAMS,	B. HERMAN,
J. E. ARMSTRONG,	C. W. JOHNS,
W. J. BACKES,	H. C. MANN,
J. B. BAKER,	J. V. NEUBERT,
W. C. BARNES,	A. W. NEWTON,
F. L. C. BOND,	R. L. PEARSON,
N. J. BOUGHTON,	W. H. PENFIELD,
C. B. BRONSON,	G. J. RAY,
E. E. CHAPMAN,	A. N. REECE,
W. C. CUSHING,	R. T. SCHOLES,
C. T. DIKE,	G. E. TEBBETTS,
W. A. DUFF,	H. R. THOMAS,
ROBERT FARIES,	C. P. VANGUNDY,
J. M. FARRIN,	J. R. WATT,
L. C. FRITCH,	J. E. WILLOUGHBY,
F. M. GRAHAM,	W. P. WILTSEE,
E. A. HADLEY,	J. G. WISHART,
C. R. HARDING,	LOUIS YAGER,
G. W. HARRIS,	J. B. YOUNG,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith its report covering the following assignments:

(1) Revision of Manual (Appendix A). Report submitted as information with recommendation that revisions be approved for publication in the Manual.

(2) Details of Mill Practice and Manufacture as they affect Rail Quality and Rail Failures, giving special attention to Transverse Fissure Failures, collaborating with the Rail Manufacturers' Technical Committee. Submitted as information (Appendices B–1 and B–2).

(3) Compilation of Statistics of all Rail Failures, making special study of Transverse Fissures. Submitted as information (Appendices C-1 and C-2).

(4) Cause and Prevention of Rail Battering, collaborating with Committee V—Track. Committee reports progress (Appendix D).

(5) Economic Value of Different Sizes of Rail. Committee reports progress (Appendix E).

(6) Specifications for Spring Washers, collaborating with Committee V—Track. Committee reports progress (Appendix F).

(7) Compilation of Information of Tests of Alloy and Heat Treated Carbon Steel Rails, collecting from railways records of such tests. Submitted as information (Appendix G).

Your Committee also gave consideration to the following additional subjects:

(8) Order of Stamping Heat Number, Rail Letter and Ingot Number on Rail, collaborating with the Rail Manufacturers. It is recommended that the addition (Appendix H) be approved for publication in the Manual.

(9) Relative Merits of Rail Sections heavier than 100 pounds from Standpoint of Economic Distribution of Metal and Strength. Committee reports progress (Appendix I).

(10) Revision of Method of Rating Rail Failures. Submitted as information (Appendix J).

(11) Specifications for Intermediate Manganese Steel Rail. Submitted as information (Appendix K).

Respectfully submitted,

THE COMMITTEE ON RAIL,

EARL STIMSON, *Chairman.*

Bulletin 344, February, 1932.

Appendix A

(1) REVISION OF MANUAL

A. F. Blaess, Chairman, Sub-Committee; W. C. Barnes, C. B. Bronson, C. T. Dike, R. Faries, L. C. Fritch, E. A. Hadley, G. W. Harris, C. R. Harding, H. C. Mann, A. W. Newton, W. H. Penfield, J. G. Wishart.

As it is now generally accepted that Rail Failures of the type defined in the Manual as "Horizontal *Fissure*" should be termed "Horizontal *Split Head*", your Committee is of the opinion that the definitions in the Manual in which the words "horizontal fissure" appear should be revised accordingly.

Consideration has been given to the suggestion that Form 402-C for reporting rail failures be revised to approximate Form 402-C as it existed before its revision in March 1931 but be amplified to include a separate list of transverse fissure failures and segregation of failures by types, rail sections, etc., and that Form 402-E for reporting transverse fissure failures be abandoned. After study of the subject the Committee is of the opinion that:

(a) having the instructions on a separate sheet as in the revision of March 1931, is a more convenient and economical way of handling these reports;
(b) on account of the present investigation, with the $250,000 expenditure by the railroads and manufacturers jointly, it seems inadvisable to change the forms at this time;
(c) changing the method of presenting the statistics so as to segregate all rails by failures, by types and sections, by weights, by types of failure, by materials and by mills, etc., would entail considerable additional expense for preparation and publication which it is inadvisable to incur under present conditions; and
(d) reporting transverse fissure failures annually instead of quarterly would crowd all the compilation work in Mr. Barnes' office into his busiest period.

The advisability of revision of Form 402-A, Report of Rail Failure in Main Track, is being investigated and a definite recommendation will be made next year.

Recommendations

1. That the definition appearing on page 139 of the Manual reading "Compound Fissure.—A horizontal *fissure* which in developing extends into a plane other than horizontal," be revised to read "Compound Fissure.—A horizontal *split head* which in developing extends into a plane other than horizontal."

2. That definition on same page reading "Horizontal *Fissure*.—A horizontal progressive fracture . . . etc." be revised to read "Horizontal *Split Head (formerly termed Horizontal Fissure)*.—A horizontal progressive fracture . . . etc."

3. That no revision be made of Form 402-C and 402-E at this time.

Appendix B–1

(2) MILL PRACTICE

Earl Stimson, Chairman, Sub-Committee; A. F. Blaess, W. C. Barnes, C. B. Bronson, E. E. Chapman, W. C. Cushing, E. A. Hadley, J. V. Neubert, G. J. Ray, W. P. Wiltsee, L. Yager.

The following is a brief resumé of the work done this year on the Joint Investigation of transverse fissure rail failures by the Rail Manufacturers and the Rail Committee:

The Engineering Experiment Station of the University of Illinois was selected for the purpose of carrying on an investigation of rail steel to determine the causes of transverse fissures and other rail failures and work out, if possible, a remedy. It is estimated that this will involve an expenditure of $50,000 a year for a period of five years which expense is being borne equally by the Rail Manufacturers and the American Railway Association. The agreement for carrying on this work was completed March 17, 1931, the Board of Trustees of the University of Illinois, the Rail Manufacturers' Technical Committee and the American Railway Association being parties thereto.

In the meantime arrangements had been made with the Baltimore & Ohio Railroad for the rolling of 5,000 tons of 130-lb. rail to be laid in track for service test purposes. An equal amount of this tonnage was rolled at four representative rail mills. Full record of the details of manufacture was made during the rolling of this tonnage, representatives of the Steel Companies, the Rail Manufacturers' Technical Committee, the Rail Committee and of the University of Illinois being present. The top, middle and bottom rails of the middle ingot of each heat were sent to the University for laboratory investigation and the remaining rails were shipped to selected locations for laying in track. A detailed report will be kept of the service of this rail in track and all failed rails will be sent to the University for investigation.

Orders are now being placed for the rolling of a like tonnage of 110-lb. rail. This rail will likewise be rolled at four mills under like supervision and will be subjected to service tests in tracks of the Atchison, Topeka & Santa Fe Railway and of another road to be selected later.

The outline of laboratory work to be done at the University of Illinois under the direction of Prof. H. F. Moore, includes the following:

(1) Routine physical tests of samples of steel cut from the sample rails sent in from the rollings;
(2) Routine chemical tests of samples of steel from the rails;
(3) Special physical tests of specimens of steel from rails;
(4) Study of internal stresses;
(5) Detection of incipient fatigue failures in rails;
(6) Production and study of growth of fissures under controlled laboratory conditions.

The work at the University is under the general direction of Prof. H. F. Moore, with Associate Prof. H. R. Thomas regularly assigned in direct charge, with a corps of assistants consisting of two physicists, one metallographer, one draftsman, one mechanician and such student help as may be required.

The work in the laboratory is being carried out in accordance with the general outline and to date has consisted of the preparation of specimens for physical tests, photomicrographs, deep etching, etc. A number of physical tests have already been made and the results are platted. The photomicrographic work is well under way. Apparatus is being prepared for applying detection methods. The program includes the trial of not only electrical and radio but also of thermal and accoustic methods. A

small testing machine has been procured and is in operation for the purpose of testing out the susceptibility of certain steels for the formation of fissures. If the results obtained from this machine point to success, a larger machine for the same purpose, which has already been designed, may be constructed.

It is the intention that not only known methods of testing will be used in the carrying out of this investigation but also that new methods will be devised as the work develops.

The Joint Committee has kept in close touch with the progress of the work at the University by meetings of the Joint Committee with Professors Moore and Thomas, and also by monthly visits to the University laboratories by assigned members from both the Manufacturers' and the Railroads' Committees.

The railroads represented on the Rail Committee and the Manufacturers will make available to the University such of their records and data of tests which the University may specifically request. Care, however, is being taken that the conduct of the investigation may remain uninfluenced by the views of the Manufacturers' representatives or of the Rail Committee.

The work at the University is well organized and is progressing. Progress in work of this kind appears rather slow at the start and definite results can hardly be expected during the coming year. The Committee, however, feels that substantial progress has been made and that worthwhile results will be obtained within the five-year period for which provision has been made.

Appendix B–2

(2) OPERATING RESULTS OF THE A.R.A. RAIL FISSURE DETECTOR CAR

By W. C. Barnes, Engineer of Tests, Rail Committee

During the past year the A.R.A. Detector Car developed marked indications of buckling due to insufficient strength in the underframing and to additional load put in the car, and it therefore became necessary to replace the original floor beams with new beams of heavier section. As this necessitated stripping the car, advantage was taken of this opportunity to give the car a complete overhauling, replacing all worn or deteriorated parts.

In the rebuilding the arrangement of apparatus was improved and numerous additions and betterments were made which experience in operation had indicated were desirable. This work was performed at the Northern Pacific shops and its cost paid for out of earnings. The resulting increase in efficiency and in mileage tested per day has fully justified the expenditure involved.

The car has been in constant demand since it was placed in service in November 1928 and on November 6th, 1931, had tested a total of 11,133 track miles in which were detected a total of 988 transverse or compound fissured rails and 3453 defective rails of all types. The average rate of detection from the start of operation to November 6th, 1931, was one transverse or compound fissured rail per 11.3 track miles and defective rails of all types were located at a rate of one per 3.2 track miles. The detection of 172 transverse or compound fissured rails and 412 defective rails of all types in 1143 track miles, at respective rates of one per 6.7 and 2.7 track miles are indicative of the work done by the car since its rebuilding. This testing was done at an average rate of 16.5 track miles per testing day.

Attention is called to the transverse fissure statistics in Appendix C–2, Fig. 1 and explanation in the text regarding the effect upon future failures in track of the present use of fissure detector cars.

Appendix C-1

(3) RAIL FAILURE STATISTICS FOR 1930

By W. C. Barnes, Engineer of Tests, Rail Committee

The Rail Failure statistics for the year ending October 31, 1930, appearing in this report, have been compiled in accordance with the standard method of basing the failure rates on mile years of service in track.

The reported tonnages and track miles of rollings for 1925 and succeeding years embodied in these statistics are as follows:

Year Rolled	*Tons*	*Track Miles*
1925	1,646,192	10,162
1926	1,866,447	11,234
1927	1,715,261	10,086
1928	1,646,855	9,510
1929	1,622,120	9,230
Total	8,496,875	50,222

Table 1 shows the average failures per 100 track miles of rail in service, which occurred in one to five years' service of all rail reported, from all mills, together with results taken from previous reports which include both Bessemer and open-hearth rail. The 1925 rollings, whose period of observation is now concluded, show an average failure rate of 110.7 per 100 track miles, which is the same as that for the rollings of 1924. It will be noted that the average rate for 5 years' service has been substantially constant for the rollings of 1922 to 1925 inclusive.

Fig. 1 shows diagrammatically the five-year averages from Table 1.

Table 2 presents a summary from 18 annual reports showing track miles of rail originally laid and total failures in addition to the failures per 100 average track miles of rail in service for periods of one to five years.

Table 3 gives the failure rates of rails from each of the mills for rollings since 1908, for one to five-year periods.

Fig. 2 shows diagrammatically the data from Table 3.

Table 4 presents a recapitulation of the performances, during the five-year period, of rails rolled at each of the mills. In this table the original track miles laid from the various rollings are given as information, the failure rates being computed from the average track miles in service during the period.

Fig. 3 presents diagrammatically the average "Per Year" failure rates per 100 average track miles in service of the 1925 to 1929 rollings from the various mills from Table 4. These rates do not take into consideration the traffic carried. Colorado shows the lowest failure rate of 6.7, followed closely by Inland with 7.0 and Dominion with 8.4. Tennessee shows the highest rate of 47.6. With the exception of Steelton with 28.9, all the other mills vary within the limits of 10.5 and 19.3.

Fig. 4 rates the performances of the mills from the same data that underlie Fig. 3 except that relative traffic density factors have been introduced into the final computations. From the annual freight gross ton miles per mile of main track of each reporting road applied to its track mile years of rail of each of the 1925 to 1929 rollings from any given mill, the weighted average traffic over all of that mill's rail which was reported on, was determined. In like manner the weighted average traffic over all rail from each of the other mills was separately determined. The mill whose rail was subjected to the lightest traffic was then considered to have unit traffic density and relative traffic density factors were determined for each of the other mills, which were applied

to the failure rates of the respective mill outputs given in Fig. 3. No claim is made that this method of rating is entirely accurate but it does give more consideration to the work which the rails from the various mills were called upon to perform than does the method of rating underlying Fig. 3 which takes no account of traffic.

The use of traffic density factors has resulted as follows:

Inland displaces Colorado in first position with the lowest rate of failure, with Carnegie second and Colorado third. Tennessee remains in the lowest position and the differences between the rates for the other mills have been reduced.

Fig. 5 presents diagrammatically the "Total" failure rates by mills and by year rolled from Table 4. The improvement in the 1928 and 1929 rollings of Tennessee compared with previous rollings is noteworthy.

Table 5 shows the average weights of rail from the various mills and from all mills. The All Mill averages reported for the years 1925 to 1929 have increased from 103.0 lb. to 111.7 lb. per yard.

TABLE I - AVERAGE FAILURES PER 100 TRACK MILES - ALL MILLS

Year Rolled	YEARS SERVICE				
	1	2	3	4	5
1908					398.1
1909				224.1	277.8
1910			124.0	152.7	198.5
1911		77.0	104.4	133.3	176.3
1912	28.9	32.1	49.3	78.9	107.1
1913	12.5	25.8	44.8	69.5	91.9
1914	8.2	19.8	32.9	50.9	74.0
1915	8.9	19.0	34.2	53.0	82.4
1916	11.8	29.2	47.7	70.6	105.4
1917	21.6	38.9	66.0	110.5	137.0
1918	8.9	27.6	54.0	92.8	125.4
1919	14.8	39.4	73.7	104.8	115.7
1920	14.2	32.4	63.1	84.5	119.6
1921	10.9	34.9	56.9	70.9	98.9
1922	15.9	34.8	55.2	80.4	110.0
1923	14.3	33.2	57.6	86.0	114.1
1924	14.0	33.4	58.3	82.0	110.7
1925	15.5	36.6	58.3	76.6	110.7
1926	17.1	41.2	64.6	102.6	
1927	18.4	37.7	69.5		
1928	11.0	28.0			
1929	14.1				

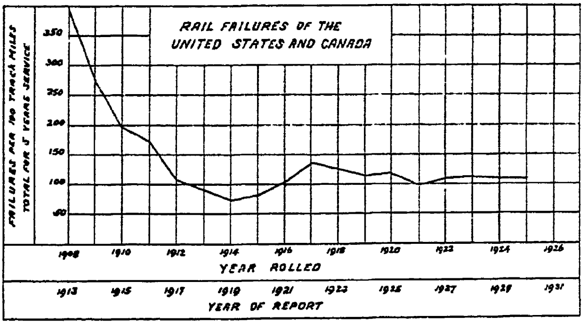


FIG. 1.

TABLE 2—Summary from Eighteen Annual Reports Showing Track Miles Originally Laid, Total Failures and Failures per 100 Average Track Miles in Service

Service	Five Years			Four Years			Three Years			Two Years			One Year		
	Trk Mls Of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls	Trk Mls of Rail Laid	Failures Total	Failures Per 100 Trk Mls
From 1913 Report															
Year Rolled Totals	3201.35	1908 12746	398.1	6340.54	1909 14208	224.1	9860.18	1910 12227	124.0	6536.06	1911 5030	77.0	7105.74	1912 2050	28.9
From 1914 Report															
Year Rolled Totals	6697.39	1909 18605	277.8	10024.85	1910 15309	152.7	6096.48	1911 6354	104.4	7610.60	1912 2431	32.1	8775.44	1913 1095	12.5
From 1915 Report															
Year Rolled Totals	11587.43	1910 22981	198.5	7980.75	1911 10635	133.5	10374.18	1912 5119	49.3	10668.59	1913 2756	25.8	7061.24	1914 584	8.2
From 1916 Report															
Year Rolled Totals	7969.41	1911 14052	176.3	10260.93	1912 8100	78.9	11355.41	1913 5076	44.8	7505.24	1914 1483	19.8	7381.29	1915 656	8.9
From 1917 Report															
Year Rolled Totals	10778.68	1912 11546	107.1	12526.60	1913 8706	69.5	7519.79	1914 2576	32.9	7344.65	1915 1395	19.0	8532.55	1916 1004	11.8
From 1918 Report															
Year Rolled Totals	11883.57	1913 10924	91.9	7752.27	1914 3948	50.9	7072.[illegible]	1915 2414	34.2	8347.44	1916 2439	29.2	7384.86	1917 1596	21.6
From 1919 Report															
Year Rolled Totals	7917.26	1914 5856	74.0	7280.51	1915 3862	53.0	8407.55	1916 4013	47.7	7615.46	1917 2962	38.9	6354.44	1918 568	8.9
From 1920 Report															
Year Rolled Totals	7346.50	1915 6057	82.4	8062.10	1916 5691	70.6	7334.40	1917 4844	66.0	6658.80	1918 1837	27.6	6676.60	1919 986	14.8
From 1921 Report															
Year Rolled Totals	7820.14	1916 8248	105.4	7025.25	1917 7765	110.5	6712.98	1918 3414	54.0	6271.82	1919 2477	39.4	7341.71	1920 1044	14.2
From 1922 Report															
Year Rolled Totals	6945.43	1917 9533	137.0	6117.93	1918 5681	92.8	6402.43	1919 4719	73.7	7550.68	1920 2448	32.4	7421.29	1921 806	10.9
From 1923 Report															
Year Rolled Totals	[illegible]756.11	1918 7[illegible]21	145.4	6388.57	1919 6[illegible]97	104.9	7[illegible]0.63	1920 4545	65.1	7338.52	1921 2568	34.9	7116.16	1922 1135	15.9
From 1924 Report															
Year Rolled Totals	5913.56	1919 6848	115.7	7271.00	1920 5146	84.5	[illegible]657.55	1921 3905	56.9	6974.38	1922 2429	34.8	9501.95	1923 1363	14.3
From 1925 Report															
Year Rolled Totals	6576.48	1920 7759	119.6	6640.45	1921 4950	70.9	6765.99	1922 3514	55.2	8692.15	1923 2791	33.2	7804.78	1924 1098	14.0
From 1926 Report															
Year Rolled Totals	7656.27	1921 7576	98.9	7116.24	1922 5594	80.4	9787.02	1923 5454	57.6	9371.49	1924 3150	33.4	10858.62	1925 1701	15.5
From 1927 Report															
Year Rolled Totals	6997.42	1922 7341	110.0	9657.09	1923 7809	86.0	9036.17	1924 5014	58.3	10344.65	1925 3620	36.6	10380.45	1926 1742	17.1
From 1928 Report															
Year Rolled Totals	6106.35	1923 9255	114.1	7916.99	1924 6493	82.0	9159.06	1925 5342	58.3	9286.90	1926 3624	41.2	8527.04	1927 1567	18.4
From 1929 Report															
Year Rolled Totals	6817.34	1924 9201	110.7	10276.58	1925 7672	76.6	11164.54	1926 6945	64.6	9951.44	1927 3675	37.7	9518.72	1928 1027	11.0
From 1930 Report															
Year Rolled Totals	10161.96	1925 10697	110.7	11224.30	1926 10662	102.6	10085.95	1927 6741	69.5	9510.08	1928 2544	28.0	9229.51	1929 1265	14.1

TABLE 3—Failures per 100 Track Miles in 1908 to 1929 Rollings in One to Five Year Service Periods by Mills

Years service	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
ALGOMA																						
1					124.0		19.0	7.1	22.7	2.0		7.3	2.6	4.[illegible]	17.4	30.3	18.5	2.3	1.2	21.1	6.7	3.6
2				419.7			43.2	11.8	42.1	2.0		26.6	16.5	13.4	51.7	74.3	48.9	7.9	7.5	45.0	15.4	
3			431.0				67.1	21.9	63.4	9.1		55.8	41.0	27.0	83.0	115.8	85.7	30.3	16.8	69.9		
4		203.7					67.9	29.1	96.8	29.7		82.9	278.6	42.4	125.5	161.8	151.5	59.6	32.3			
5	482.9		15.8				321.4	84.0	139.9	62.9		36.7	472.0	66.2	184.4	276.3	226.2	113.3				
[illegible] - (Carnegie)																						
1					12.3	8.9	3.5	1.8	4.9	6.1	6.2	8.5	7.0	3.3	8.4	4.1	10.6	17.1	17.2	11.2	10.3	6.2
2				71.6	30.9	19.4	11.9	8.6	13.2	19.5	41.6	35.9	15.1	8.6	20.4	13.9	33.8	41.9	30.9	25.4	31.5	
3			96.9	108.9	56.3	33.8	16.4	16.9	26.8	39.3	53.8	36.5	34.4	23.6	38.0	26.0	48.4	57.0	50.9	42.7		
4		104.1	112.9	123.1	78.4	62.9	25.4	29.2	45.6	72.3	73.7	46.5	59.4	37.5	48.7	45.9	63.0	74.6	81.5			
5		157.1	101.1	165.6	38.8	80.0	48.8	43.7	69.7	32.2	125.5	60.5	87.8	52.8	65.5	56.2	73.3	102.5				
CAMBRIA - (Bethlehem)																						
1					17.1	26.7	15.8	6.3	7.3	23.3	32.9	33.3	37.6	13.8	10.1	12.6						
2				73.7	41.8	49.5	37.7	19.6	25.9	26.9	35.5	75.2	44.2	43.2	47.9	36.3						
3			96.5	126.1	74.3	78.3	61.9	34.1	35.7	112.9	248.0	62.6	96.8	101.4	60.[illegible]	63.3						
4		244.8	136.4	227.7	108.9	106.2	64.3	88.7	73.7	211.0	369.7	103.2	158.5	156.8	72.0	97.3						
5		325.6	201.0	257.2	140.9	120.1	137.7	111.6	157.6	394.2	507.4	152.7	223.1	237.4	156.0	123.5						
DOMINION																						
1												5.7		60.9				2.6	1.3	6.3	5.3	6.4
2											60.0	102.3						2.6	5.8	14.2	15.9	
3											149.0	185.9						2.7	24.0	25.3		
4											420.9	298.3						7.1	49.9			
5											482.7	396.0						22.1				
ENSLEY - (Tennessee)																						
1					7.3	5.7	7.5	6.0	16.6	17.3	16.4	14.1	39.9	37.5	42.7	42.4	32.6	35.5	34.6	48.4	12.5	17.9
2				14.9	32.9	16.5	16.6	16.0	37.1	36.7	34.6	34.2	83.1	84.9	106.7	100.4	82.4	96.1	89.9	113.6	31.9	
3			32.4	25.1	43.3	24.5	29.0	30.5	61.1	58.2	79.9	100.7	149.3	149.7	172.0	136.2	136.4	160.3	150.5	222.4		
4		11.1	47.8	40.8	64.5	41.6	44.2	48.0	82.2	102.5	145.1	132.3	189.8	184.7	204.7	194.5	181.5	168.7	241.1			
5	86.5	83.7	56.2	61.7	65.2	57.3	60.8	70.9	183.4	109.5	146.5	79.7	232.4	231.6	264.9	245.3	249.6	252.3				
GARY - (Illinois) includes So. Works to 1919 inclusive.																						
1					7.4	10.0	11.6	10.7	11.1	9.1	2.5	11.5	5.4	4.2	5.0	6.6	5.4	5.6	8.2	12.8	12.0	11.3
2				67.3	23.2	21.9	30.0	21.9	26.0	19.9	10.8	26.8	13.3	16.2	11.2	17.2	10.9	10.9	22.9	20.4	24.2	
3			88.4	94.0	39.2	44.0	47.3	40.9	43.9	46.3	18.5	43.7	36.9	27.0	20.6	32.5	18.8	20.9	42.7	30.9		
4		151.9	136.8	107.7	64.6	52.1	83.6	56.1	70.7	75.5	45.4	77.1	55.6	41.7	29.4	51.1	28.2	34.5	68.4			
5		219.7	206.2	178.6	100.0	91.5	98.3	76.8	97.3	107.7	50.3	107.1	84.2	58.9	42.6	72.9	44.4	50.3				
INLAND																						
1																7.6	2.6	5.6	10.7	2.5	4.6	4.1
2															19.0	12.8	6.7	10.4	16.7	7.8	12.1	
3															35.7	20.4	16.7	21.8	30.8	13.4		
4															55.1	29.5	22.2	30.1	44.3			
5															75.7	33.4	38.2	44.2				
LACKAWANNA - (Bethlehem)																						
1					4.8	17.2	1.8	10.5	8.9	16.6	7.4	22.8	14.5	3.8	4.0	18.6	18.5	16.7	24.6	37.1	8.4	28.0
2				21.5	20.1	21.4	10.0	23.8	25.5	21.6	23.7	51.9	27.1	19.0	13.6	35.9	29.3	56.0	41.9	33.0	17.5	
3			41.7	57.1	29.6	51.9	24.5	38.1	40.1	46.6	43.8	77.4	50.6	41.3	22.6	57.6	50.6	50.9	50.3	49.3		
4		100.1	90.2	138.6	67.1	74.0	49.3	57.3	58.0	78.3	65.5	86.7	74.1	62.4	36.6	90.8	59.5	86.8	78.6			
5	145.5	117.8	148.9	[illegible]	68.6	115.3	78.7	73.1	76.9	104.5	93.2	163.0	99.0	83.2	49.9	108.6	97.2	122.3				
MARYLAND - (Bethlehem)																						
1					11.2	28.6	13.3	24.5	30.7	160.5	23.7	34.2	0.0	0.0				11.2	31.0	62.1	20.2	15.6
2				32.9	5.8	74.1	23.2	60.2	61.8	214.2	59.2	52.8	2.3	7.2			1.5	62.6	72.9	55.5	37.6	
3			69.6	49.5	18.1	88.4	31.4	99.6	92.6	360.5	113.6	60.8	11.9	25.3			6.0	61.9	55.2	85.4		
4			104.8	58.5	8.6	117.0	36.2	138.1	96.6	425.5	139.1	30.8	11.9				35.4	55.9	55.8			
5			163.7	67.4	110.8	159.7	62.9	231.4	180.3	445.5	210.3	106.9				180.0	65.4	77.1				
MINNEQUA - (Colorado)																						
1					18.3	3.9	3.7	4.6	5.8	8.4	6.5	5.0	9.3	9.2	12.0	7.0	4.3	3.8	2.8	2.1	3.8	2.0
2				15.8	40.9	11.0	7.6	7.7	15.7	12.5	13.1	18.5	27.6	31.7	27.1	29.5	9.6	7.2	8.9	4.6	22.7	
3			19.6	21.0	35.6	26.0	14.1	15.1	74.5	25.7	39.7	32.9	75.0	50.6	58.9	54.3	28.7	19.1	20.0	12.3		
4		22.4	23.4	[illegible]	91.3	46.6	27.3	34.4	53.4	51.5	109.0	[illegible]	96.5	72.7	111.6	91.5	39.2	32.0	30.6			
5	45.5	34.2	40.9	84.3	117.6	82.1	42.0	80.3	78.1	42.6	184.8	90.2	138.5	97.8	134.6	108.9	57.8	47.6				
STEELTON - (Bethlehem)																						
1					5.3	3.6	8.2	6.3	35.6		2.4	46.9	56.3	4.9	10.3	10.0	16.6	7.8	20.2	13.7	21.3	40.8
2				34.6	15.6	21.0	21.1	15.1	46.1		9.2	79.6	35.5	12.2	18.7	16.7	38.9	34.3	41.0	34.4	56.1	
3			41.4	79.6	27.5	24.7	29.4	27.3	[illegible]		20.7	139.6	70.2	25.3	20.1	31.2	65.3	50.6	62.3	77.2		
4		86.3	110.9	119.0	46.8	47.2	76.0	48.4	136.1		50.6	175.1	96.7	41.6	29.7	41.1	80.1	77.5	107.8			
5	77.9	101.4	123.8	145.2	60.4	71.2	49.7	53.0	171.7		[illegible]	[illegible]	139.5	66.1	48.9	49.4	95.9	113.2				
SAUCON - (Bethlehem)																						
1					11.9	13.4	3.6	17.1	17.7	39.0	19.5	31.2	10.4	12.9	56.6							
2				113.3	32.[illegible]	20.3	[illegible]	24.5	47.4	59.2	57.7	72.2	57.5	62.4	77.2							
3			174.0	196.3	39.1	54.0	16.0	41.0	75.2	34.6	78.4	105.0	56.5	85.4	130.6							
4		456.1	145.0	251.7	[illegible]	77.2	21.6	86.0	110.9	127.7	91.3	160.7	84.5	114.3	177.4							
5	103.7		330.9	359.8	[illegible]	99.2	35.0	95.4	152.0	157.6	[illegible]	213.9	35.6	143.6	223.4							
ALL MILLS																						
1					40.3	11.6	6.0	6.8	11.7	21.6	6.9	14.6	14.2	10.8	15.9	14.3	14.0	15.5	17.1	18.4	11.0	14.1
2				[illegible]	28.9	24.8	18.9	19.0	27.9	38.9	27.6	[illegible]	32.4	34.9	34.6	32.2	23.4	36.6	41.2	37.7	28.0	
3			81.3	[illegible]	46.0	43.[illegible]	30.2	30.8	47.7	66.0	54.0	77.7	63.1	56.9	55.2	57.6	56.3	56.3	64.6	69.5		
4		162.6	137.1	111.2	74.2	66.5	47.4	53.0	70.6	110.5	92.5	104.6	64.5	70.9	80.4	66.0	68.0	76.6	102.6			
5	37[illegible]	198.[illegible]	154.0	161.9	102.7	93.[illegible]	74.0	82.4	106.4	177.0	125.4	115.7	119.6	98.3	110.0	114.1	110.7	110.7				

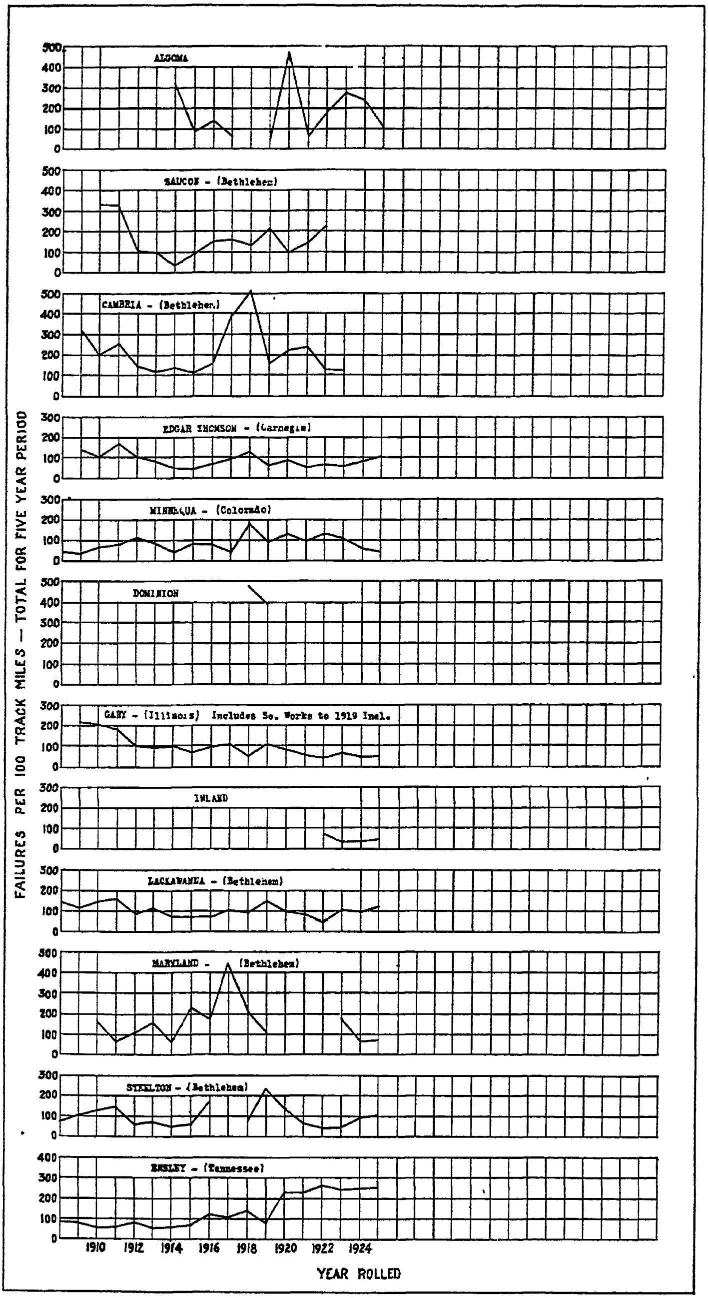


FIG. 2—Record of Failures per 100 Track Miles for Five Years' Service for Rollings from 1908 to 1925

Table 4—Recapitulation—Totals and Averages Grouped by Mills. Track Miles —Represent Quantities Originally Laid. Failures to Date—Computed by Mile Years of Rail in Service

Year Rolled	Original Trk. Mls.	Total Failures	Failures to Date Per 100 Av. Trk. Mls. Total	Per Year	Original Trk. Mls.	Total Failures	Failures to Date Per 100 Av. Trk. Mls. Total	Per Year
	Algoma				Dominion			
1925	479.15	543	113.3	22.7	113.01	25	22.1	4.4
1926	319.35	103	32.3	8.1	154.24	77	49.9	12.5
1927	188.97	132	69.9	23.3	63.30	16	25.3	8.4
1928	793.86	122	15.4	7.7	119.35	19	15.9	8.0
1929	772.26	28	3.6	3.6	62.86	4	6.4	6.4
Totals	2553.60	928	Ave.	10.5	512.76	141	Ave.	8.4
	Edgar Thomson (Carnegie)				Ensley (Tennessee)			
1925	1130.21	1109	102.5	20.5	1889.94	4523	252.3	50.5
1926	1457.75	1159	81.5	20.4	2093.87	4887	241.1	60.2
1927	1463.20	605	42.7	14.2	1539.40	3458	222.4	74.1
1928	1196.94	359	31.5	15.8	1394.99	421	31.9	15.9
1929	1292.20	75	6.2	6.2	1029.23	182	17.9	17.9
Totals	6558.30	3257	Ave.	15.3	8047.43	13471	Ave.	47.6
	Gary (Illinois)				Inland			
1925	2313.09	1127	50.5	10.1	678.45	278	44.2	8.8
1926	2471.08	1638	68.4	17.1	788.80	302	44.3	11.1
1927	2194.32	668	30.9	10.3	790.17	109	13.4	4.5
1928	2162.19	494	24.2	12.1	748.00	87	12.1	6.1
1929	1933.60	217	11.3	11.3	691.94	26	4.1	4.1
Totals	11064.38	4144	Ave.	12.4	3697.36	802	Ave.	7.0
	Lackawanna (Bethlehem)				Maryland (Bethlehem)			
1925	1176.26	1237	122.5	24.5	534.98	379	77.1	15.4
1926	1244.23	858	78.6	19.6	499.03	258	53.8	13.5
1927	957.81	403	49.3	16.4	509.56	420	85.4	28.5
1928	621.66	97	17.5	8.8	426.99	160	37.6	18.8
1929	805.05	220	28.0	28.0	507.13	79	15.6	15.6
Totals	4767.19	2815	Ave.	19.4	2477.69	1296	Ave.	18.3
	Minnequa (Colorado)				Steelton (Bethlehem)			
1925	880.61	414	47.6	9.5	956.16	1052	113.2	22.6
1926	1108.69	336	30.6	7.7	1087.19	1064	107.8	26.9
1927	1263.07	154	12.3	4.1	1036.15	776	77.2	25.7
1928	1056.97	232	22.7	11.3	1019.11	563	56.1	28.1
1929	1145.10	22	2.0	2.0	990.14	400	40.8	40.6
Totals	5434.44	1158	Ave.	6.7	5088.75	3855	Ave.	26.9
	All Mills							
1925	10161.96	10697	110.7	22.2				
1926	11234.50	10662	102.6	25.6				
1927	10085.95	6741	69.5	23.2				
1928	9510.08	2544	28.0	14.0				
1929	9229.51	1253	14.1	14.1				
Totals	50221.80	31897	Ave.	20.0				

Table 5—Average Weights of Rails Compiled from Tonnages Used in This Report

Mill	1925	1926	1927	1928	1929
Algoma	101.0	100.7	100.4	100.8	101.2
Dominion	101.4	101.4	101.9	115.0	127.0
Edgar Thomson (Carnegie)	111.3	114.6	113.9	118.8	120.8
Ensley (Tennessee)	91.0	97.4	100.0	100.3	102.6
Gary (Illinois)	101.4	103.6	107.5	110.4	110.4
Inland	103.9	102.0	104.5	110.8	111.0
Lackawanna (Bethlehem)	101.2	108.7	107.5	110.5	115.9
Maryland (Bethlehem)	97.6	104.8	115.7	114.7	113.6
Minnequa (Colorado)	104.0	98.2	102.3	101.3	104.8
Steelton (Bethlehem)	126.0	123.1	122.9	122.2	123.9
All Mills	103.0	105.7	108.1	110.2	111.7

Diagram Showing Mill Ratings Compiled by Usual Method

Mill	Failures per 100 Ave. Trk. Mls. per Year
ALGOMA	10.5
DOMINION	8.4
EDGAR THOMSON (Carnegie)	15.3
ENSLEY (Tennessee)	47.6
GARY (Illinois)	12.4
INLAND	7.0
LACKAWANNA (Bethlehem)	19.3
MARYLAND (Bethlehem)	18.3
MINNEQUA (Colorado)	6.7
STEELTON (Bethlehem)	28.9
ALL MILLS - Average	20.0

Fig. 3—Average Failure Rates for the Rollings of 1925 to 1929 Inclusive, Classified by Mills

Diagram Showing Mill Ratings as Altered by Use of Traffic Density Factors

Mill	Failures per 100 Ave. Trk. Mls. per Year per Unit of Traffic Density
ALGOMA	10.5
DOMINION	7.5
EDGAR THOMSON (Carnegie)	4.3
ENSLEY (Tennessee)	26.9
GARY (Illinois)	5.6
INLAND	2.6
LACKAWANNA (Bethlehem)	8.7
MARYLAND (Bethlehem)	6.9
MINNEQUA (Colorado)	4.5
STEELTON (Bethlehem)	8.6
ALL MILLS - Average	8.4

Fig. 4—Average Failure Rates for the Rollings of 1925 to 1929, Inclusive, Classified by Mills, Changed from those Presented in Fig. 3

Diagram Showing Failures per 100 Average Track Miles by Mill and by Year Rolled for Periods Ending October 31, 1930

Mill	Year Rolled	Failures per 100 Average Track Miles
ALGOMA	1925	113.3
	1926	32.3
	1927	69.9
	1928	15.4
	1929	3.6
DOMINION	1925	22.1
	1926	49.9
	1927	25.3
	1928	15.9
	1929	6.4
EDGAR THOMSON (Carnegie)	1925	102.5
	1926	81.5
	1927	42.7
	1928	31.5
	1929	6.2
ENSLEY (Tennessee)	1925	252.3
	1926	241.1
	1927	222.4
	1928	31.9
	1929	17.9
GARY (Illinois)	1925	50.3
	1926	68.4
	1927	30.9
	1928	24.2
	1929	11.3
INLAND	1925	44.2
	1926	44.3
	1927	13.4
	1928	12.1
	1929	4.1
LACKAWANNA (Bethlehem)	1925	122.3
	1926	78.6
	1927	49.3
	1928	17.5
	1929	28.0
MARYLAND (Bethlehem)	1925	77.1
	1926	53.8
	1927	85.4
	1928	37.6
	1929	15.6
MINNEQUA (Colorado)	1925	47.6
	1926	30.6
	1927	12.3
	1928	22.7
	1929	2.0
STEELTON (Bethlehem)	1925	113.2
	1926	107.8
	1927	77.2
	1928	56.1
	1929	40.8
ALL MILLS (Average)	1925	110.7
	1926	102.6
	1927	69.5
	1928	26.0
	1929	14.1

Fig. 5—Accumulated Failures for Rollings from 1925 to 1929 Inclusive

Appendix C-2

(3) TRANSVERSE FISSURE STATISTICS

By W. C. Barnes, Engineer of Tests, Rail Committee

The report year which formerly ended on January 31st was changed by action taken at the last convention to coincide with the calendar year and to effect this change this report shows all cumulative records to December 31st, 1930, and all data presented for the year 1930 includes 11 months only from January 31st, 1930, to December 31st, 1930.

These statistics constitute a cumulative record of 50,746 transverse fissure failures which have been reported up to and including December 31st, 1930. They include all fissured rails reported whether located by actual breakage in track or detected by inspection or test.

Table 1 corresponds with Table 1 of last year's report and shows the number of transverse fissure failures reported by each of 54 roads and the years in which such failures occurred. The data included for 1930 are for the 11 months from January 31, 1930 to December 31, 1930.

The accumulated total reported to December 31st, 1930 from all rollings was 50,746 compared with a total to January 31st, 1930 of 44,035 or an addition during the 11 months of 6711, making an average rate of 20 failures per day. This is an increase of 473 over the preceding year's total of 6238. This increase of 473 is more than accounted for by the detection during the 11 months of 1434 fissured rails which is 956 more than were reported detected in the preceding year. Increase in the number of detected fissures is not an indication of greater prevalence of fissures but of increased use of methods of locating them in track before actual breakage.

Such detected fissure failures as have been reported to date are included in the fiscal years "1929", "1930" and in the "Total" and "Grand Total" columns and those detected in 1930 are shown separately by roads under the column headed "Det. 1930". Many fissured rails were detected during the year on roads which do not report fissure failures and hence are not included in Table 1.

Fig. 1 presents graphically the total fissure failures reported each year. The dotted curve includes "detected" fissured rails while the solid curve excludes them. As was forecast in last year's report the trend of the solid line now indicates that the usual annual increase in actual failures in track is being checked by the removal of detected fissured rails before breakage, by the use of heavier rail sections and by decrease in traffic. The effect, however, appears exaggerated in Fig. 1 because of the shorter period included in 1930, but if the 11 months total of 5277 undetected failures be prorated for 12 months it would become 5757 as compared with a total of 5760 for the year 1929.

Table 2 corresponds with Table 2 of last year's report. It shows all transverse fissure failures accumulated from year rolled to December 31st, 1930, for each year's rollings from each mill, unweighted by tonnage output of mills, by density of traffic or by years of service. The data shown for 1930 are for eleven months.

This table is most useful in comparing the failures in the various rollings from any one mill. Of the earlier rollings those of 1910, 1912, 1913 and 1917 from all mills continue to show the largest number of accumulated failures while of the more recent rollings, those of 1926 have produced the greatest number principally due to failures in Tennessee rail. The 1926 rollings also produced the greatest number of failures in 1930.

Fissure failures reported during the last few years as occurring in the first year of service are as follows:

29 failures in 1925 from 1925 Rollings, All Mills
50 failures in 1926 from 1926 Rollings, All Mills
114 failures in 1927 from 1927 Rollings, All Mills
58 failures in 1928 from 1928 Rollings, All Mills
106 failures in 1929 from 1929 Rollings, All Mills
33 failures in 1930 from 1930 Rollings, All Mills (11 months)

Of the 33 failures in 1930 rollings 25 occurred in Steelton rail and of these only 6 were detected failures.

Table 3 corresponds with the Table 3 of last year's report and shows the rate of accumulated failures on selected roads per 100 original track miles per year from year rolled to December 31st, 1930. The data included are for the rollings of 1923 to 1927 inclusive and are segregated by mill and by year rolled. No account is taken in this Table of differences in density of traffic on the rails from the individual mills. Table 3 includes a total of 7720 fissure failures in 34,676 miles of track.

The 1930 failures included in Table 3, Fig. 2 and Fig. 3 are those which occurred during the twelve months of the new fiscal year which is from December 31, 1929 to December 31, 1930, while those for former years are for the old fiscal years ending January 31st. Both the 1929 and 1930 failures therefore include those that occurred in January, 1930. This procedure was employed to preserve the "Per Year" basis of Table 3, Fig. 2 and Fig. 3.

Fig. 2 shows graphically the average rates of failure by mills from Table 3. Maryland and Tennessee have the highest rates, 11.09 and 10.73 respectively, and Colorado the lowest with 0.43. The Maryland average rate was necessarily based on a comparatively small track mileage and was materially affected by a moderate number of detected fissure failures.

Fig. 3 shows graphically the average rates of failure for the 1923 to 1927 rollings of the various mills from Table 3 and Fig. 2, modified by the use of relative traffic density factor; the lightest average traffic which prevails on Colorado rail being considered 100 per cent. A factor for each reporting road based on its annual gross freight ton miles per mile of main track was applied to the mile years of rail laid on that road from any given mill. A weighted average traffic density for all rail from that mill upon all roads was then determined. The relative traffic density on all rail from each of the various mills was then obtained and applied to the failure rate for the respective mill output as given in Table 3 and Fig. 2.

No claim is made for the entire accuracy of this system of rating but it does give more consideration to the work which the failed rails from the various mills were called upon to perform than does the system used in Table 3 and Fig. 2 which takes no account of differences in traffic carried.

The weighting for relative traffic density which is used in Fig. 3 has improved the standing of those mills whose rails carried the heaviest traffic notably Carnegie and Pennsylvania (Steelton).

Table 1
Transverse Fissure Failures
by Railroads and Year Failed

Railroad	Prior 1919	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Total	1930	Grand Total	Det.* 1930
A.T. & S.F.	40	25	177	220	134	126	81	79	71	98	126	91	1265	142	1410	
A.C.L.									11	9	27	25	72	87	159	66
Ban. & Aroos.									11	2	0	4	17	7	24	
B. & Eastern							0	0	0	0	0	0	0	0	0	
Boston & Albany	4	17	23	30	25	15	10	9	5	12	8	31	187	54	241	23
Boston & Maine						35	69	72	78	70	44	34	402	52	454	17
B. & O.						212	297	369	253	458	405	481	2475	345	2820	
B. R. & P.					9	11	9	16	15	17	26	41	144	27	171	
Can. Nat.									13	-	-	-	13	-	13	
Can. Pac.		4		8	16	59	86	168	277	174	160	108	1050	136	1186	
Cent. of Ga.	106	52	23	41	31	29	24	40	20	20	42	92	520	160	680	80
C.R.R. of N.J.										54	58	95	187	108	295	35
C. & E.I.									4	-	22	69	95	18	113	
C. & O.				6	26	46	49	81	208	104	165	186	844	557	1401	376
C. & N.W.									85	63	47	78	273	132	405	31
C.B. & Q.		1	7	34	101	87	-	-	-	-	-	-	250	-	230	
C.M. St.P. & P.	2		6	5	14	11	11	13	5	9	26	54	156	26	182	
C.R.I. & P.	10	2	11	25	37	75	73	114	96	97	90	143	775	111	886	
C.C.C. & St.L.					2	1	1	47	21	11	36	44	163	44	207	
D.L.& W.	474	193	240	169	91	80	73	113	128	86	92	139	1678	98	1976	
El Paso & S.W.					8	5	(See	Sou.	Pac.)				14	-	14	
Erie					15	43	89	100	118	148	128	262	903	158	1061	2
Great Northern										58	221	175	454	214	668	25
Hocking Valley					13	53	82	38	2	4	30	94	316	**	316	
Illinois Central	11	35	121	190	372	556	419	501	614	658	615	622	4714	565	5279	126
Ind. Harbor Belt						1	3	3	0	0	0	0	7	0	7	
L. & H.R.				1		4	4	16	33	10	7	8	63	3	66	
L. & N.E.						32	0	0	0	0	1	0	33	0	33	
Lehigh Valley					57	89	113	92	75	75	55	60	616	39	655	
Long Island				2	8	7	11	2	3	6	(See	P.R.R.)	39	-	39	
L.A. & S.L.							1	7	12	36	39	34	129	40	169	
L. & N.	474	9	17	33	43	77	90	75	141	295	374	557	2185	450	2635	167
Mich. Cent.						2	6	11	13	10	6	15	64	18	82	
M.K.T.				2	11	13	17	29	26	33	33	40	204	42	247	11
Mo. Pac.					2	8	-	-	-	-	-	-	10	-	10	
Mobile & Ohio									16	30	59	22	129	26	155	
N.C. & St. L.	10		1	2	2	8	5	7	3	15	15	34	102	24	126	2
N.Y.C. (East)	415	64	66	93	136	107	126	165	233	257	295	327	2316	272	2586	63
N.Y.C. (West)			1	18	37	16	31	62	49	44	34	54	346	59	405	21
N.Y.C. & St. L.						2	-	-	-	-	-	-	2	-	2	
N.Y., N.H. & H.					12	26	26	57	63	34	27	66	315	107	422	67
N.Y.O. & W.										59	62	63	184	60	244	
N. & W.					3	17	45	29	18	16	18	25	171	63	234	
N. Pacific					42	39	120	161	152	184	166	208	1072	131	1203	
Pennsylvania	2244	1114	1129	1104	904	649	801	785	868	741	574	584	11197	764	11961	194
Reading					52	112	107	91	36	44	39	53	532	57	589	
R.F. & P.									0	0	0	4	4	0	4	
Rutland								3	2	1	0	2	8	3	11	
Sou. Pac.	57	9	6	130	118	143	175	242	335	397	530	500	2643	589	3232	131
Southern Ry.						24	6	13	51	123	191	205	613	201	814	
Tem. & No. Ont.										0	0	0	0	0	0	
Union Pacific				36	262	557	498	473	356	289	341	428	3260	457	3707	
Virginian											10	12	22	7	29	
Western Md.								65	111	164	212	57	609	255	864	
All Roads	3847	1545	1650	2149	2584	2382	3257	4136	4596	4993	5458	6238	44035	6711	50746	1434

Due to change in termination of the fiscal year from January 31st to December 31st, the 1930 failures included in this report are for the eleven months from January 31st, 1930 to December 31st, 1930.
*Fissured rails "detected" in 1930 prior to breakage. These are included in the "1930" and "Grand Total" columns. A total of 478 detected in 1929 are also included in the "1929", "Total" and "Grand Total" columns. Additional fissure failures were "detected" on non-reporting roads.
**Included in C. & O.

Fig. 1 - Total Fissure Failures Reported Each Year
(1930 includes 11 months only)

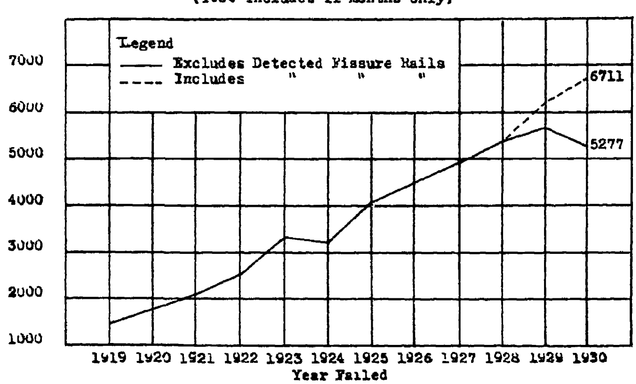


Table 2

Accumulated Transverse Fissure Failures
reported to Dec. 31, 1930 by Year Rolled and by Mill
(Includes fissured rails detected before actual failure in track)

Year Rolled	Unknown			Algoma			Saucon (Bethlehem)			Cambria (Bethlehem)			Edgar Thomson (Carnegie)			Minnequa (Colorado)			Dominion			Krupp (German)		
	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total
Unk.	58	1	59	8	2	10	27	6	33	35	4	39	33	2	35	35	0	35	2	0	2			
1889																								
1890																								
1891																								
1892										2	0	2	1	0	1									
1893										1	0	1												
1894										6	0	6												
1895										5	0	5	1	0	1									
1896																								
1897										10	0	10	5	0	5									
1898										15	1	16	4	0	4									
1899										14	0	14	7	0	7									
1900										15	0	15	7	0	7									
1901										26	0	26	17	0	17									
1902	2	0	2				2	0	2	62	0	62	35	0	36	1	0	1						
1903		1	1							58	0	58	64	2	66									
1904	6	0	6							26	0	26	40	0	40	1	0	1						
1905	2	0	2	5	1	6				28	2	30	35	1	36									
1906		1	1				2	0	2	67	0	67	44	0	44				8	1	9			
1907				2	0	2	10	0	10	70	0	70	29	0	29	2	0	2						
1908				4	1	5	214	8	222	14	0	14				1	0	1	72	5	77			
1909				5	0	5	1366	32	1398	75	0	75	33	1	34	3	0	3	9	3	12			
1910	10	0	10	8	1	9	644	52	696	108	3	111	16	6	22	360	19	379						
1911				8	3	11	902	31	933	350	1	351	54	0	54	309	46	355						
1912	6	2	8	6	1	7	135	7	142	603	19	622	57	4	61	71	4	75	53	2	55			
1913	6	0	6	6	0	6	297	13	310	514	16	530	66	3	69	34	6	40	4	0	4			
1914	2	0	2	25	3	28	143	1	144	320	9	329	33	3	36	65	15	80	9	0	9			
1915	2	0	2	421	40	461	283	6	289	127	0	127	36	8	44	180	5	185						
1916	1	0	1	93	8	101	354	9	363	84	7	91	76	4	80	357	39	396						
1917	2	2	4	6	0	6	249	8	257	143	9	152	61	3	64	343	84	427						
1918	2	0	2	379	5	384	79	5	84	78	3	81	70	1	71	59	14	73	71	3	74			
1919	1	0	1	350	19	369	230	17	247	9	0	9	20	3	23	26	11	37	46	4	50			
1920				80	3	83	63	3	66	62	1	63	72	8	80	168	92	260						
1921	1	0	1	10	6	16	170	6	176	147	12	159	100	11	111	63	54	117	2	0	2			
1922				27	23	50	86	9	95	66	5	71	160	16	176	24	9	33						
1923	96	0	96	57	19	76				42	7	49	102	20	122	32	8	40						
1924	66	0	66	28	27	55							92	27	119	23	9	32						
1925	55	0	55	2	0	2							113	44	157	10	19	29		1	1			
1926	22	0	22		2	2							198	64	262	5	8	13	1	3	4	1	2	3
1927	25	0	25										111	78	189	1	5	6						
1928	1	0	1	1	4	5							22	24	46		1	1						
1929													1	7	8				1	0	1			
1930														1	1									
Totals	366	7	373	1531	168	1699	5256	213	5469	3182	99	3281	1815	341	2156	2173	448	2621	278	22	300	1	2	3

Due to change in termination of the fiscal year from January 31st to December 31st, the 1930 failures included in this report are for the eleven months from January 31st, 1930 to December 31st, 1930.

Table 2 (Concluded)

Accumulated Transverse Fissure Failures
reported to Dec. 31, 1930 by Year Rolled and by Mill
(Includes fissured rails detected before actual failure in track)

Year	Gary* (Illinois)			Inland (Inland)			Lackawanna** (Bethlehem)			Lorain			Maryland (Bethlehem)			Steelton (Bethlehem)			Ensley (Tennessee)			All Mills		
Rolled	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total	Prior	1930	Total
Unk	145	7	152	2	0	2	20	5	25				10	1	11	7	0	7	107	19	126	489	45	534
1899																2	0	2				2	0	2
1890							2	0	2				1	0	1	5	0	5				8	0	8
1891							4	0	4							3	0	3				8	0	8
1892													1	0	1	2	0	2				5	0	5
1893													4	0	4							5	0	5
1894													1	0	1	3	1	4				10	1	11
1895							1	0	1							2	0	2				9	0	9
1896	1	1	2				4	2	6				1	0	1	5	0	5	1	0	1	10	3	13
1897							9	0	9				1	0	1	7	0	7				32	0	32
1898							24	0	24				2	0	2	8	0	8				53	1	54
1899							13	0	13				3	0	3	18	0	18				55	0	55
1900	2	0	2										6	0	6	11	0	11				41	0	41
1901	2	0	2				19	4	23				13	0	13							77	4	81
1902	1	0	1				2	2	4	1	2	3	33	0	33							139	4	143
1903	1	0	1				2	1	3				60	2	62				27	0	27	212	6	218
1904	2	2	4				54	33	87				21	5	26				197	2	199	347	42	389
1905	6	0	6				14	1	15	3	0	3	28	2	30	5	0	5	324	1	325	450	8	458
1906	4	0	4				6	0	6	5	0	5	51	2	53	1	1	2	52	0	52	240	5	245
1907	23	0	23				25	1	26				77	0	77				60	0	60	298	1	299
1908	6	2	8				7	1	8	1	0	1	2	0	2	2	1	3	32	0	32	355	18	373
1909	764	59	823				71	2	73				60	9	69	109	1	110	6	0	6	2501	107	2608
1910	2104	124	2228				182	47	229				108	7	115	113	1	114	141	6	147	3794	266	4060
1911	243	9	252				339	8	347				215	11	226	114	4	118	157	7	164	2691	120	2811
1912	1357	51	1408				825	25	850				172	15	187	81	11	92	105	12	117	3471	153	3624
1913	1361	87	1438				821	54	875	1	0	1	420	31	451	96	10	106	99	25	124	3715	245	3960
1914	343	28	371				713	16	729				131	10	141	110	1	111	192	13	205	2086	99	2185
1915	514	47	561				342	29	371				421	62	483	145	4	149	73	7	80	2544	208	2752
1916	711	60	771				109	8	117				411	63	474	29	3	32	231	16	247	2456	217	2673
1917	1847	182	2029				132	8	140				670	85	755	4	2	6	186	20	206	3643	403	4046
1918	442	101	543				119	10	129				90	7	97	12	2	14	327	29	356	1728	180	1908
1919	937	172	1109				76	16	98				51	10	61	95	7	102	372	94	466	2313	253	2566
1920	541	70	611				145	29	174							141	18	159	151	38	189	1442	262	1685
1921	350	106	456	1	0	1	120	28	148					2	2	195	50	245	110	46	156	1269	321	1590
1922	146	44	190	139	34	173	121	31	152				3	2	5	59	6	65	266	74	340	1097	253	1350
1923	370	132	508	54	24	78	372	82	454				1	2	3	89	25	118	260	77	337	1475	294	1869
1924	187	84	271	43	23	66	107	38	145				2	4	6	150	50	200	333	173	506	1031	425	1466
1925	145	71	216	54	30	84	169	80	249				87	41	128	153	60	213	541	198	739	1329	544	1873
1926	127	105	232	99	33	132	123	98	221				70	61	131	111	93	204	621	233	854	1378	702	2080
1927	108	40	148	4	7	11	115	121	236				125	121	246	94	115	209	404	155	559	987	642	1629
1928	6	8	14	2	1	3	45	46	91				67	51	118	74	100	174	35	34	69	253	269	522
1929	1	7	8	2	4	6	18	36	54				19	204	223	22	82	104	42	27	69	106	367	473
1930		5	5											1	1		25	25		1	1		33	33
Totals	12787	1604	14391	400	156	556	5270	860	6130	11	2	13	5438	811	4255	2075	671	2746	5452	1307	6759	44035	6711	50746

Due to change in termination of the fiscal year from January 31st to December 31st, the 1930 failures included in this report are for the eleven months from January 31st, 1930 to December 31st, 1930.
*Includes South Works prior to 1920.
**Prior to 1905 was Scranton Mill of Lackawanna Iron & Steel Co.

Table 3- Average Transverse Fissure Failure Rates on Selected Roads per 100 Original Track Miles per Year from Year Rolled to 12/31/30, by Mill and Year Rolled.

Year Rolled	E.Thom (Carn)	Ensley (Tenn)	Gary (Ill)	Inl. (Inl)	Lack (Beth)	Mary (Beth)	Minn (Colo)	Penn (Beth)	All Mills
1923	1.69	4.77	4.85	2.27	5.54	-	1.17	1.28	3.47
1924	2.08	7.65	2.98	2.33	3.15	-	0.56	3.67	3.49
1925	[illegible]	12.92	2.27	1.98	5.88	5.84	0.29	4.06	4.64
1926	4.99	15.16	2.67	3.33	5.76	17.98	0.20	5.08	5.97
1927	4.12	17.75	1.27	2.28	9.20	16.03	0.22	7.63	6.27
Ave.	2.90	10.73	2.86	2.44	5.63	11.09	0.43	3.94	4.54

Fig. 2 - Average Failure Rates Classified by Mills

Mill	Average Fissure Failures to 12/31/30 per Year, per 100 Trk. Miles of Rollings 1923 to 1927
Edgar Thomson (Carnegie)	2.90
Ensley (Tennessee)	10.73
Gary (Illinois)	2.86
Inland (Inland)	2.44
Lackawanna (Bethlehem)	5.63
Maryland (Bethlehem)	11.09
Minnequa (Colorado)	0.43
Pennsylvania (Bethlehem)	3.94
All Mills - Average	4.54

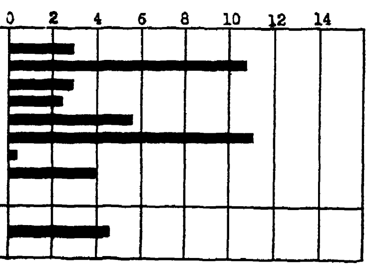
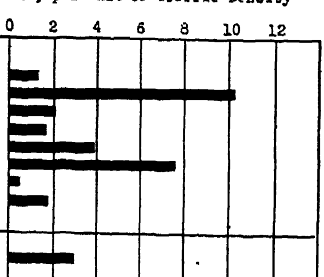


Fig. 3- Average Failure Rates by Mills Altered by Traffic Density Factors

Mill	Relative Traffic Density	Average Fissure Failures to 12/31/30 per year, per 100 Trk.Miles of Rollings 1923 to 1927, per Unit of Traffic Density
Edgar-Thomson (Carnegie)	216	1.34
Ensley (Tennessee)	107	10.2
Gary (Illinois)	139	2.06
Inland (Inland)	141	1.73
Lackawanna (Bethlehem)	146	3.85
Maryland (Bethlehem)	146	7.60
Minnequa (Colorado)	100	0.43
Pennsylvania (Bethlehem)	217	1.82
All Mills - Average	156	2.91



Appendix D

(4) CAUSE AND PREVENTION OF RAIL BATTERING, COLLABORATING WITH COMMITTEE V—TRACK

F. M. Graham, Chairman, Sub-Committee; W. J. Backes, W. C. Barnes, N. J. Boughton, W. A. Duff, B. Herman, J. V. Neubert, R. L. Pearson, W. H. Penfield, R. T. Scholes, J. R. Watt, J. E. Willoughby.

This Sub-Committee is proceeding with the development of heat treating rail ends for the purpose of eliminating or at least reducing the rate of rail end batter. Field tests are being started and methods of heat treatment are being developed. The Sub-Committee feels that satisfactory progress is being made and that a final report may be submitted in 1933.

Appendix E

(5) ECONOMIC VALUE OF DIFFERENT SIZES OF RAIL

J. M. Farrin, Chairman, Sub-Committee; Lem Adams, J. B. Baker, W. C. Barnes, F. L. C. Bond, R. Faries, C. R. Harding, C. W. Johns, H. C. Mann, G. J. Ray, A. N. Reece, H. R. Thomas, W. P. Wiltsee.

Your Committee reports progress on this subject.

Appendix F

(6) SPECIFICATIONS FOR SPRING WASHERS, COLLABORATING WITH COMMITTEE V—TRACK

Lem Adams, Chairman, Sub-Committee; J. E. Armstrong, W. C. Barnes, C. T. Dike, F. M. Graham, B. Herman, J. V. Neubert, R. L. Pearson, G. E. Tebbetts, J. G. Wishart, J. E. Willoughby.

Your Committee reports progress on this subject.

Appendix G

(7) TESTS OF ALLOY AND HEAT TREATED CARBON STEEL RAILS

J. B. Young, Chairman, Sub-Committee, J. E. Armstrong, W. C. Barnes, E. E. Chapman, W. A. Duff, C. W. Johns, G. J. Ray, A. N. Reece, R. T. Scholes, C. P. Van Gundy, J. R. Watt.

INTERMEDIATE MANGANESE RAIL.—Attached herewith will be found summaries showing the amounts of intermediate manganese rail purchased during 1931, also amounts previously purchased and total amounts to date tabulated both by roads and by mills (Exhibit 1).

A summary of the failures to date is attached herewith (Exhibit 2). From the summary it will be noted that the majority of failures reported are head failures and transverse fissures.

No additional information regarding the relative wear in service was received from the reporting roads.

The C. B. & Q. report that they have experienced an epidemic of horizontal fissures in certain rollings, but do not state their number. They state that these failures appear to be due to a martensitic structure in the heads of the rail. An investigation of this condition to determine the cause is being carried on by the Robert W. Hunt Company and the University of Illinois. Under date of September 25, 1931, H. H. Morgan of Robert W. Hunt Company advises that they had received no formal report as yet from the University of Illinois, but that he would communicate with the Chairman as soon as anything further developed.

The users of intermediate manganese rail have been experimenting during the past year with compositions varying slightly from those previously reported in the 1930 Proceedings.

No additional information regarding the relative merits of intermediate manganese rail as compared with standard Open-Hearth rail has been received.

This report is submitted as information.

Heat Treated Rails.—Owing to the retrenchment policy of the railroads very few heat treated rails have been purchased during 1931, and no methods of treatment have been developed.

Below you will find a summary of the tonnage of heat treated rails purchased in 1931:

Road	*Tons Purchased*
Chesapeake & Ohio	1000
Pennsylvania	3586 (equal to 5727—131-lb. rails)
Reading Company	500

The composition specified was that of the A.R.E.A. standard specifications for Open-Hearth carbon steel rail.

The Bethlehem Steel Company has installed a proof-testing device at its Steelton Plant for the purpose of proof-testing all heat-treated rails. This device consists of a series of rollers. Two rollers on the same plane are spaced far enough apart so that a third roller can be placed above the lower rollers and midway between them. The upper roller can be raised or lowered so that a rail passing over the rollers can be stressed to nearly its elastic limit. If the rail being tested contains any strains or cracks resulting from the heat-treatment, it will break when subjected to this test. From information submitted none of the heat-treated rails which passed this proof test have failed in service.

Several heat-treated rails laid by the Reading Company early this year developed head failures due to quenching cracks and as a result the entire 500 tons were returned to Steelton for proof-testing. Those which passed the proof-test have not as yet been placed in track. All reporting roads state that the heat-treated rails have not been in service long enough to enable them to make any comparison with untreated rail as to wear, etc.

This report is submitted as information.

Exhibit 1

Distribution of Intermediate Manganese Rail by Mills

Company	*Plant*	*Previously Reported*	*Reported during 1931*	*Total Tonnage*
Algoma	S. S. Marie	4783	233	5016
Bethlehem	Lackawanna	125611	13156	138767
Bethlehem	Maryland	9742		9742
Bethlehem	Steelton	145039		145039
Carnegie	Edgar Thomson	23124	590	23714
Colorado	Minnequa	88361	43051	131412
Dominion	Sydney	5341	497	5838
Illinois	Gary	178818	2792	181610
Inland	Ind. Harbor	60394	993	61387
Tennessee	Ensley	9057		9057
All Mills		650270	61312	711582

Distribution of Intermediate Manganese Rail by Roads

Road	*Previously Reported*	*Reported during 1931*	*Total Tonnage*
A. T. & S. F.	69104	43051	112155
Boston & Maine	68256		68256
Canadian National	8828		8828
Chesapeake & Ohio	500		500
C. B. & Q.	126550		126550
D. L. & W.	100369	6000	106369
Kansas City Southern	5694		5694
Louisville & Nashville	2000		2000
M. K. T.	500		500
Northern Pacific	1705		1705
N. Y. C. Lines	238218	12261	250479
Pennsylvania	942		942
Reading	300		300
Illinois Central	5250		5250
Southern Pacific	20344		20344
Southern Railway	1710		1710
All Roads	650270	61312	711582

Exhibit 2

Failures to Date Intermediate Manganese Rail

Road		*Split Heads*	*Cracked Heads*	*Square Break*	*Trans. Fiss.*	*Split Webs*
B. & M.	130-lb. R.E.	107	3			
	100-lb. N.H.	31	5			
Can. Nat'l.	100-lb. H.F.	70	1	1		
L. & N. (No report).						
N.P.	130-lb. R.E.	11				
	100-lb. R.E.	26				
Southern	100-lb. T.F. 6	2				
D.L.W.	130-lb. Steelton	289	19	35	20	25
	130-lb. Lacka.	263	8	1	2	6
	105-lb. Steelton	1		4	2	4
	105-lb. Lacka.	Broken Bases—4				
	130-lb. Steelton	Broken flaws—2, Broken Bases—4.				
	130-lb. Lacka.			Broken Bases—5.		
K.C.S.	115-lb.	2				
	100-lb.	3				

Road		Split Heads	Cracked Heads	Square Break	Trans. Fiss.	Split Webs
A.T. & S.F.	110-lb.	12	Scrappy heads—7 Bolt holes —2 Head check —1 Seamy head —1 Flowed metal —1			

		Split Heads	Crushed Heads	Other Breaks	Trans. Fiss.	Web	Base
N.Y.C.	127-lb. Lacka.	60	268	6	23	8	3
	105-lb. Lacka.	9	55	1	50	5	3
	127-lb. Gary	40	94	1	6	3	
B. & A.	105-lb. Lacka.	13	7		11	3	
P. & L. E.	115-lb. Carn.	11	4				
Big Four	105-lb. Gary	8	44		6	3	
	127-lb. Gary						
Mich. Cent.	127-lb. Gary		1				

Appendix H

(8) ORDER OF STAMPING OF HEAT NUMBER, RAIL LETTER AND INGOT NUMBER ON RAIL

A. F. Blaess, Chairman, Sub-Committee; W. C. Barnes, C. B. Bronson, C. T. Dike, R. Faries, L. C. Fritch, E. A. Hadley, G. W. Harris, C. R. Harding, H. C. Mann, A. W. Newton, W. H. Penfield, J. G. Wishart.

There appears in the 1931 annual report of the Committee a plate illustrating the recommended typical branding and stamping (1931 Proceedings, page 353). The stamping is shown under the heading "Typical stamping showing recommended data, arrangement thereof, and design of letters and numerals to be used."

After this plate was printed and just prior to the Committee's presentation of the report some of the rail manufacturers objected to the arrangement of the stamping and in consequence the words "arrangement thereof" in the heading above mentioned were eliminated when the report was read at the convention (see discussion 1931 Proceedings, page 817). The matter has been further discussed with the manufacturers during the past year and they have withdrawn their objections to the arrangement desired by the Committee.

Recommendation

(1) That the words "arrangement thereof" appearing at the end of the first line under the heading "Typical Stamping" on page 353 of the 1931 Proceedings, which words were eliminated at the last convention, be reinstated for publication in the Manual.

Appendix I

(9) RELATIVE MERITS OF RAIL SECTIONS HEAVIER THAN 100 LB. FROM STANDPOINT OF ECONOMICAL DISTRIBUTION OF METAL AND STRENGTH

A. F. Blaess, Chairman, Sub-Committee; W. C. Barnes, C. B. Bronson, C. T. Dike, R. Faries, L. C. Fritch, E. A. Hadley, G. W. Harris, C. R. Harding, H. C. Mann, A. W. Newton, W. H. Penfield, J. G. Wishart.

Your Committee has this subject under investigation and reports progress.

Appendix J

(10) REVISION OF METHOD OF RATING RAIL FAILURES

W. C. Barnes, Chairman, Sub-Committee; A. F. Blaess, W. C. Cushing, C. B. Bronson, G. W. Harris, C. R. Harding, A. W. Newton, L. Yager, W. P. Wiltsee.

For several years past it has been the practice to include in the General Rail Failure and Transverse Fissure Statistics certain mill rating charts (Appendices C–1, Fig. 4 and C–2, Fig. 3) in which the failure rates on a simple mileage basis have been modified by the use of average traffic density factors derived from the I.C.C. reports on main line average traffic density.

The method used has been explained in the text accompanying said statistics, in which it has been definitely stated that, "No claim is made that this method of rating is entirely accurate but it does give more consideration to the work which the rails from the various mills were called upon to perform than does the method of rating which takes no account of traffic".

This method has been criticised from the standpoint that it does not necessarily produce the same results as would be produced by use of the actual traffic over the rails in question. The impracticability of obtaining from any considerable number of reporting roads the actual traffic over the various lots of rail included in their reports, coupled with the desirability of maintaining the mass of the statistics, was the reason for the use of the approximate method.

During the past year Mr. Blaess prepared a comparison of mill ratings for rail used on certain districts of the Illinois Central System based on (1) the average traffic as used in our statistics, and on (2) the actual traffic over the rails involved. In the comparison the mills are found to be rated in the same order by both methods, indicating that the use of average traffic density factors gives sufficiently accurate information (Exhibit 1). The Committee would welcome the making of similar comparisons by other roads.

After investigation, your Committee reports that no method of improving the present basis of rating has been found practicable and hence makes no recommendation regarding a change in the method now used.

This report is submitted as information.

Appendix K

(11) SPECIFICATIONS FOR INTERMEDIATE MANGANESE STEEL RAIL

J. B. Young, Chairman, Sub-Committee; J. E. Armstrong, W. C. Barnes, E. E. Chapman, W. A. Duff, C. W. Johns, G. J. Ray, A. N. Reece, R. T. Scholes, C. P. Van Gundy, J. R. Watt.

While not regularly assigned by the Committee on Outline of Work, the subject of preparation of specifications for intermediate manganese steel rail has been investigated by your Committee. It finds that the largest purchasers and users of intermediate manganese steel rail are not in agreement as to the composition best suited for this material and that they will continue to experiment with compositions differing from those which they have been purchasing in the past. The preparation of specifications for intermediate manganese steel will therefore be deferred until definite knowledge of the most suitable composition is available.

Exhibit 1

ILLINOIS CENTRAL SYSTEM.

COMPARISON OF RAIL FAILURES OF T.C.I., INLAND, AND GARY RAIL TO OCTOBER 31, 1929, FOR YEARS' ROLLINGS 1924 TO 1928 INCLUSIVE.

WEIGHT AND SECTION - 90-LB. ARA-A.

1. Manufacturer	2. Year Laid	3. Districts	4. Track Miles	5. Mile Years	6. Rail Failures to 10-31-29	7. Failures per 100 mile years	8. Traffic Density (a) IC RR Gross tons Frt.& Pass. (Million)	8. Traffic Density (b) ICC Report Gro.Ton Mi. per mile per day	9. IC RR Failures per 100 Mi.yrs. per 10 million gross tons	10. I.C. RR Relative rates of failure %	11. Failures per 100 Mi. Yr. per unit traffic density 1.64	12. I.C.C. Report Relative Rates of Failure %
TCI	1924	Fulton	6.24	31.20	31							
"	1925	"	14.00	56.00	78							
"	1926	"	23.39	70.17	125							
"	1927	"	6.42	12.84	1							
"	1928	"	.08	.08	00							
		Total	50.13	170.29	235	138.03	18,606	16,400	74.18	-	84.10	-
"	1924	Canton and	17.79	88.95	4							
"	1925	McComb	19.00	76.00	18							
"	1926	"	20.05	60.15	35							
"	1927	"	12.83	25.66	7							
"	1928	"	9.45	9.45	00							
		Total	79.12	260.21	64	24.59	8,903	16,400	27.62	-	14.99	-
TCI	1924 to 1928	Fulton, Canton and McComb	129.25	430.50	299	69.45	12,740	16,400	54.51	187%	42.33	168%
Gary	1924	Dubuque	22.42	89.29	31							
"	1925	"	15.61	51.20	25							
"	1926	"	30.45	87.98	42							
"	1927	"	20.65	41.30	16							
"	1928	"	24.77	24.77	7							
		Total	113.90	294.54	121	41.08	14,063	16,400	29.21	-	25.05	-
"	1924	Centralia	4.32	21.60	33							
"	1925	"	8.63	34.52	9							
"	1926	"	7.49	22.47	10							
"	1927	"	2.30	4.60	00							
"	1928	"	.36	.36	1							
		Total	23.10	83.55	53	63.47	15,631	16,400	40.66	-	38.70	-
Gary	1924 to 1928	Dubuque and Centralia	137.00	378.09	174	46.03	14,390	16,400	31.98	109%	28.06	111%
Inland	1924	Springfield	6.59	32.95	5							
"	1925	"	2.72	10.88	1							
"	1926	"	8.01	24.03	8							
"	1927	"	4.00	8.00	0							
"	1928	"	1.78	1.78	0							
		Total	23.01	77.64	12	15.45	11,836	16,400	13.06	-	9.42	-
"	1924	Centralia	16.30	81.51	33							
"	1925	"	1.74	6.96	2							
"	1926	"	18.78	56.34	46							
"	1927	"	1.66	3.32	00							
"	1928	"	.13	.13	00							
		Total	38.61	148.26	81	54.69	15,531	16,400	26.51	-	12.95	
Inland	1924 to 1928	Centralia & Springfield	61.71	225.90	93	41.17	14,140	16,400	29.11	100%	25.10	100%

NOTE: This table covers six districts which have been selected in order to determine the rate of failure of rails from the different mills, based on using traffic density factor, as compared with rate of failure based on using actual tonnage carried on those districts.

REPORT OF COMMITTEE V—TRACK

C. R. Harding, *Chairman;*
H. G. Aberg,
C. A. Alden,
W. G. Arn,
W. H. Bettis,
W. H. Bevan,
L. H. Bond,
R. W. E. Bowler,
C. W. Breed,
H. W. Brown,
W. G. Brown,
E. W. Caruthers,
H. R. Clarke,
J. E. Deckert,
J. W. DeMoyer,
L. W. Deslauriers,
J. J. Desmond,
J. H. Dymock,
J. A. Ellis,
F. S. Hales,
W. J. Harris,
O. F. Harting,
F. W. Hillman,
J. E. Hogan,
E. T. Howson,
L. J. Hughes,
W. G. Hulbert,
T. T. Irving,
F. J. Jerome,
H. D. Knecht,
J. de N. Macomb,
F. H. Masters,
C. M. McVay,
J. C. Mock,
J. B. Myers,
A. J. Neafie,
J. V. Neubert,
G. A. Peabody,
C. J. Geyer, *Vice-Chairman;*
G. H. Pegram,
O. C. Rehfuss,
C. J. Rist,
W. L. Roller,
E. M. T. Ryder,
I. H. Schram,
G. L. Sitton,
G. J. Slibeck,
G. L. G. Smith,
Theo. Speiden, Jr.
H. C. Stiff,
G. M. Strachan,
C. R. Strattman,
J. B. Strong,
E. D. Swift,
T. P. Warren,
J. R. Watt,
H. N. West,
Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents reports on the subjects assigned, as follows:

(1) Revision of Manual (Appendix A).

(1–A) Revision of specifications for steel and malleable iron tie plates (Appendix B).

(1–B) Specifications for soft steel track spikes (Appendix B).

(2) String lining of curves by the chord method, and preparation of tables suitable for the use of trackmen (Appendix C).

(3) Plans and specifications for track tools, collaborating with Committees I—Roadway, II—Ballast, and XXII—Economics of Railway Labor (Appendix D).

(4) Plans for switches, frogs, crossings, slip switches, etc. (Appendix E).

(5) Track construction in paved streets, collaborating with Committee IX—Grade Crossings (Appendix F).

(6) Corrosion of rail and fastenings in tunnels, collaborating with Committee IV—Rail (Appendix G).

(7) Gage of track and elevation of curves, with reference to the use of roller bearings on railway equipment, collaborating with the Mechanical Division, A.R.A. (Appendix H).

(8) Effect of existing materials in track on the design of tie plates and punching thereof, together with the interrelation of slotting of joint bars and size of track spikes, collaborating with Committee IV—Rail (Appendix I).

(9) Standard wheel flanges, treads and gages, collaborating with the Mechanical Division, A.R.A. and the Association of Manufacturers of Chilled Car Wheels (Appendix J).

Action Recommended

(1) That revisions recommended in Appendix A be approved for publication in the Manual.

(2) That Plan No. 4–A in Appendix D be adopted as recommended practice and published in the Manual, and that the subject be continued.

(3) That Plans Nos. 258 to 269, inclusive, 326, 503 and 504, in Appendix E, be adopted as recommended practice and published in the Manual, and that Plans Nos. 256 and 257 in Appendix E be received as information, as outlined in this report, and that the subject be continued.

Bulletin 344, February, 1932.

(4) That Plans Nos. 987 and 988 in Appendix F be received as information, as outlined in this report, and that the subject be continued.

(5) That Plan No. 790 in Appendix J be adopted as recommended practice, published in the Manual, and that the subject be discontinued.

(6) That the report in Appendix B (Item 1–A) be received as information and the subject discontinued.

(7) That the progress reports in Appendices B (Item 1–B), C, G, H and I, be received as information and the subjects continued.

Respectfully submitted,

THE COMMITTEE ON TRACK,

C. R. HARDING, *Chairman.*

Appendix A

(1) REVISION OF MANUAL

C. R. Harding, Chairman, Sub-Committee; C. J. Geyer.

The Committee recommends the revision of Index to A.R.E.A. Trackwork Plans and Specifications, pages I, II, III and IV, dated March, 1930, by the substitution of revised Index dated 1932, pages 1, 2, 3 and 4, listing existent plans and specifications and including the new plans presented in Appendix E and omitting plans that are recommended below for withdrawal. The plan dates and dates of adoption or acceptance as information are not listed; this information is shown on the plans. The last issue of each plan is identified by serial number as explained on the first page of the Index.

Page 4 (the Index Supplement), describes revisions to 49 plans to make them consistent. These plans are identified on Index pages 1, 2, and 3 by the letter "x" following the serial number.

The Committee recommends the revision of Plans Nos. 273 to 279 inclusive, dated November, 1928, adopted March, 1929, by the substitution of revised plans of the same numbers, dated September, 1931. The revisions consist of the correction of minor inconsistencies and errors and the addition of a reference to new plan No. 326, presented in Appendix E, showing details of tie and base plates for frogs.

The Committee recommends the revision of Plans Nos. 401, 402 and 403 dated September 15, 1919, adopted March, 1920, and Plan No. 404 dated September, 1929, adopted March, 1930, by the substitution of revised plans of the same numbers, dated September, 1931. The revisions consist of the extension of the long point rail 4 inches ahead of the ½ inch point, as is done with the bolted rigid frogs, and of the straight planing of the spring wing rail base instead of notching, and of the correction of notes and other minor inconsistencies.

The Committee recommends that Plan No. 501, dated November, 1920, adopted March, 1921, covering details of Guard Rails 8′–3″, 11′–0″ and 16′–6″, be withdrawn, as substitute Plans Nos. 503 and 504, covering Guard Rails, tee rail design with bent and planed flares, 8′–3″, 11′–0″ and 13′–0″ long (with revised flares and other modifications), are being offered for adoption as recommended practice in Appendix E.

These plans specify the minimum length guard rails, with suitable fixtures, for use with frogs of various numbers and types for which we have plans. Longer length guard rails will only be required for special conditions or locations.

The Committee recommends the revision of Plan No. 502 dated November, 1920, adopted March, 1921, by the substitution of a revised plan of the same number dated September, 1931. The revised plan is a complement to Plans Nos. 503 and 504, presented in Appendix E.

It is also recommended that the plans listed below be withdrawn:

No. 305—Detail of Plates for Nos. 6, 7, 8 and 10 Bolted Frogs, adopted March, 1920.
No. 308—Details of Plates for Nos. 11, 16 and 20 Bolted Rigid Frogs, adopted March, 1920.
No. 321—Tie layout Standard Length Rigid Frogs for one piece guard rail 6 ties 19" to 20" spacing, suspended joints. Information March, 1926.
No. 420—Data for laying out Spring Rail Frogs, adopted March, 1923.

These plans are no longer needed as the information on them is now covered by Plans Nos. 256 to 269 inclusive, 271 to 279 inclusive, 281, 282, 283, 291 and 292; also by new Plan No. 326 showing details of tie and base plates for frogs of medium weight and heavy rails.

The Committee also recommends the revision of track tool Plans Nos. 1, 2, 6, 8, 9, 10, 12, 17, 18, 19 and 21, dated September, 1929, by the substitution of revised plans of the same numbers, dated September, 1931.

In the redrafting of the track tool plans by several railroads for standardization purposes, several minor omissions and errors in dimensioning were discovered and referred to the attention of the Sub-Committee. Changes in the adopted plans have, therefore, been made as follows:

Plan No. 1—Clay Pick—Minor correction in drawing.
Plan No. 2—Tamping Pick—Minor correction in drawing.
Plan No. 6—Rail Tongs—Minor change in dimension.
Plan No. 8—Timber Tongs—Additional dimensions shown.
Plan No. 9—Spike Pullers—Extra knob added for heavy weight rail.
Plan No. 10—Rail Fork—Small change in plan.
Plan No. 12—Track Adz—Change in dimension.
Plan No. 17—Track Chisel—Design No. 2—Change in dimension.
Plan No. 18—Tie Plug Punch—Change in dimension.
Plan No. 19—Round Track Punch—Change in dimension.
Plan No. 21—Track Tool Handles—Minor change in notes.

Inasmuch as the corrections in these plans are of a minor nature, and in the interest of economy, it is considered unnecessary to reprint the plans at this time. Copies of the corrected plans are on file in the Secretary's office, and anyone interested may inspect same on application.

Appendix B

(1-A) REVISION OF SPECIFICATIONS FOR STEEL AND MALLEABLE IRON TIE PLATES

E. D. Swift, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, R. W. E. Bowler, J. E. Deckert, F. J. Jerome, J. de N. Macomb, J. V. Neubert, G. L. Sitton, G. L. G. Smith.

1. The Committee has had under consideration revision of Specifications for Steel Tie Plates to provide for shoulder height tolerance.

Investigation appears to demonstrate some impracticability in using like tolerances for plates with shoulders parallel with the direction of rolling and for plates with shoulders perpendicular to the direction of rolling, and because of this situation and furthermore because the absence of shoulder height tolerances from the specifications as they exist does not appear to have impaired their value, it is recommnded the subject be discontinued.

2. The Committee has had under consideration suggestion originating with the Malleable Iron Research Institute that the Specifications for Malleable Iron Tie Plates be revised as to minimums for tensile strength, yield point and elongation so as to con-

form to the higher requirements contained in the A.R.A. Mechanical Division Specifications for Malleable Iron.

In view of the fact that the A.R.A. Mechanical Division now has under consideration revisions of its specifications for malleable iron and, further, because the comparatively large use of this material in mechanical service and its very small use in tie plates results in investing the question with smaller values from the track viewpoint, it is recommended, with a view to eventually specifying Mechanical Division requirements, that further action be deferred until after the Mechanical Division has taken definite action on the proposal it now has under consideration.

(1-B) REVISION OF SPECIFICATIONS FOR SOFT STEEL TRACK SPIKES

E. D. Swift, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, R. W. E. Bowler, J. E. Deckert, F. J. Jerome, J. de N. Macomb, J. V. Neubert, G. L. Sitton, G. L. G. Smith.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year, and it is recommended that the subject be continued.

Appendix C

(2) STRING LINING OF CURVES BY THE CHORD METHOD AND PREPARATION OF TABLES SUITABLE FOR THE USE OF TRACKMEN

C. W. Breed, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bettis, L. H. Bond, F. S. Hales, W. J. Harris, F. W. Hillman, J. E. Hogan, E. T. Howson, C. R. Strattman, E. D. Swift.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year, and it is recommended that the subject be continued.

Appendix D

(3) PLANS AND SPECIFICATIONS FOR TRACK TOOLS

G. M. Strachan, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bevan, L. H. Bond, E. W. Caruthers, H. R. Clarke, J. J. Desmond, F. S. Hales, F. W. Hillman, E. T. Howson, L. J. Hughes, T. T. Irving, J. B. Myers, J. V. Neubert, C. J. Rist, W. L. Roller, G. L. G. Smith, J. R. Watt.

In the 1929 Supplement to the Manual, Plan No. 4, dated September, 1929, covers wrenches for old style nuts. Plan No. 4–A, dated February, 1930, is submitted herewith, as new plan to cover wrenches for the new style A.S.A. nuts.

The Committee has given further study to the chemical and physical specifications for track tools, also specifications covering hickory handles, but is not yet in position to make definite recommendations. Plans covering track shovels and ballast forks are also under consideration.

Conclusions

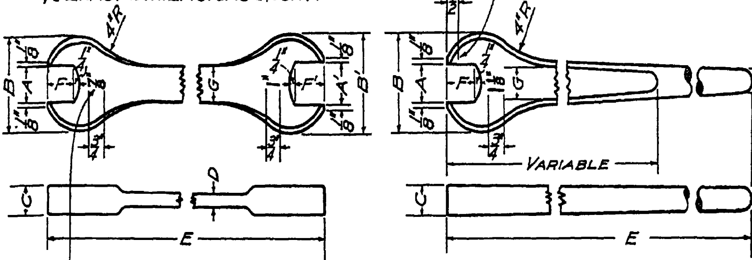
The Committee recommends that the following plan, submitted herewith, be adopted as recommended practice and printed in the Manual, supplementing present Plan No. 4 for old style nuts:

Plan No. 4–A, dated February, 1930, Track Wrenches for A.S.A. Nuts.

The Committee recommends that the subject be continued.

TOLERANCE –
2% ON LENGTH
5% ON CROSS SECTION
ALL WRENCH JAWS SHALL BE MILLED TO EXACT DIMENSIONS SHOWN

ARROW SHOWING POINT WHERE HARDNESS IS TAKEN ON ALL WRENCHES.



NOTE:– SIZE OF BOLT SHALL BE STAMPED PLAINLY ON ONE SIDE OF HEAD IN POSITION AS SHOWN.

NOTE:– SINGLE END WRENCH WILL BE FURNISHED WITH END TAPERED FOR LAST 6" TO 1/2" DIA AT END WHEN SO SPECIFIED.

BOLT SIZES	WIDTH OF NUT	A	A'	B	B'	C	D	E	F	F'	G
3/4" & 7/8"	1 1/8" & 1 5/16"	1 3/16	1 3/8	3 3/8	3 7/8	15/16	1/2	36"	1 1/8	1 1/8	1 1/2
7/8" & 1"	1 5/16 & 1 1/2"	1 3/8	1 9/16	3 7/8	3 7/8	15/16	1/2	36"	1 1/8	1 1/4	1 1/2
1" & 1 1/8"	1 1/2 & 1 11/16	1 9/16	1 3/4	3 7/8	4"	15/16	9/16	42"	1 1/4	1 7/16	1 1/2
1 1/8 & 1 1/4"	1 11/16 & 1 7/8"	1 3/4	1 15/16	4"	4 3/8	*	9/16	42"	1 7/16	1 5/8	1 1/2
1 1/4 & 1 3/8	1 7/8" & 2 1/16	1 15/16	2 1/8	4 3/8	4 7/8	1"	9/16	48"	1 5/8	1 13/16	1 1/2
* Note "C" = 15/16" on 1 1/8" end, 1" on 1 1/4" end											

BOLT SIZES	WIDTH OF NUT	A	B	C	D	E	F	G
3/4"	1 1/8"	1 3/16	3 3/8	15/16	3/4"	30"	1 1/8	1 1/2
7/8"	1 5/16	1 3/8	3 7/8	15/16	3/4	30"–36"	1 1/8	1 1/2
1"	1 1/2"	1 9/16	3 7/8	15/16	7/8	36"	1 1/4	1 1/2
1 1/8"	1 11/16	1 3/4	4"	15/16	7/8	36"–42"	1 7/16	1 1/2
1 1/4"	1 7/8"	1 15/16	4 3/8	1"	7/8	42"	1 5/8	1 1/2
1 3/8"	2 1/16	2 1/8	4 7/8	1"	7/8	42"–48"	1 13/16	1 1/2
1 1/2"	2 1/4"	2 5/16	5 1/8	1"	7/8"	48"	1 7/8	1 1/2

BRINELL – 375–450
ROCKWELL – 45–51
SCLEROSCOPE – 57–66

GENERAL NOTE – ABOVE JAW OPENINGS DESIGNED TO FIT NEW A.S.A. NUTS – Jan. 1930.

A. R. E. A.
TRACK WRENCHES
FEB. 1930. PLAN NO. 4-A

Appendix E

(4) PLANS FOR SWITCHES, FROGS, CROSSINGS, SLIP SWITCHES, ETC.

O. F. Harting, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, H. G. Aberg, C. A. Alden, W. G. Arn, L. H. Bond, H. W. Brown, W. G. Brown, E. W. Caruthers, J. W. DeMoyer, L. W. Deslauriers, J. H. Dymock, J. A. Ellis, W. G. Hulbert, T. T. Irving, J. de N. Macomb, F. H. Masters, J. C. Mock, J. B. Myers, A. J. Neafie, G. A. Peabody, O. C. Rehfuss, C. J. Rist, E. M. T. Ryder, G. L. Sitton, G. J. Slibeck, Theo. Speiden, Jr., H. C. Stiff, G. M. Strachan, C. R. Strattman, J. B. Strong, E. D. Swift, H. N. West.

The plans presented in this Appendix, and in Revision of the Manual in Appendix A coming under this subject, have been prepared in conference with the Standardization Committee of the Manganese Track Society.

Last year the Committee presented as information to invite criticism, Plans Nos. 260 and 262 showing general details of the various types of No. 8 and No. 10 frogs for medium weight rails with uniform tie spacings for one-piece manganese and other guard rails. All subsequent suggested changes that were agreed upon have been incorporated in Plan No. 262 and it has been rearranged so that it will reproduce on a standard size A.R.E.A. sheet without fold. Taking Plan No. 262 as typical, the entire series, Plans Nos. 256 to 269 inclusive, has been completed.

Plans Nos. 258 to 269 inclusive, submitted herewith, are now presented for adoption as recommended practice; and Plans Nos. 256 and 257, submitted herewith, are offered as information.

This series of plans corresponds to the series of plans of frogs for heavy rails, Nos. 271 to 279 inclusive, 281 to 283 inclusive, 291 and 292.

Plan No. 326, showing details of tie plates and base plates for railbound manganese steel, bolted rigid and solid manganese steel frogs for medium weight and heavy rails, is submitted herewith for adoption as recommended practice.

Plans Nos. 503 and 504 of Guard Rails, tee rail design with bent and planed flares, are submitted herewith for adoption as recommended practice. These plans supersede previously adopted Plan No. 501 showing details of guard rails, which plan is recommended for withdrawal in Appendix A.

Conclusions

The Committee recommends that the following plans submitted herewith be adopted as recommended practice and printed in the Manual:

Plan No. 258, dated September, 1931, No. 6 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 259, dated September, 1931, No. 7 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 260, dated September, 1931, No. 8 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 261, dated September, 1931, No. 9 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 262, dated September, 1931, No. 10 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 263, dated September, 1931, No. 11 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 264, dated September, 1931, No. 12 frogs for medium weight rails, railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

Plan No. 265, dated September, 1931, No. 14 frogs for medium weight rails, railbound manganese steel and bolted rigid.

Plan No. 266, dated September, 1931, No. 15 frogs for medium weight rails, railbound manganese steel and bolted rigid.

Plan No. 267, dated September, 1931, No. 16 frogs for medium weight rails, railbound manganese steel and bolted rigid.

Plan No. 268, dated September, 1931, No. 18 frogs for medium weight rails, railbound manganese steel.

Plan No. 269, dated September, 1931, No. 20 frogs for medium weight rails, railbound manganese steel.

Plan No. 326, dated September, 1931, Details of tie plates and base plates for railbound manganese steel, bolted rigid and solid manganese steel frogs for medium and heavy weight rails.

Plan No. 503, dated September, 1931, Guard rails, tee rail design, with bent flares.

Plan No. 504, dated September, 1931, Guard rails, tee rail design, with planed flares.

The Committee also recommends that the following plans submitted herewith be received as information:

Plan No. 256, dated September, 1931, No. 4 frogs for medium weight rails, railbound manganese steel, bolted rigid, and solid manganese steel.

Plan No. 257, dated September, 1931, No. 5 frogs for medium weight rails, railbound manganese steel, bolted rigid and solid manganese steel.

The Committee recommends that this subject be continued.

NOTE.—For plans enumerated on pages 583, 584 and 585, see Bulletin 344, February, 1932.

Appendix F

(5) TRACK CONSTRUCTION IN PAVED STREETS

E. W. Caruthers, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, C. A. Alden, H. W. Brown, W. G. Brown, J. E. Deckert, J. W. DeMoyer, O. F. Harting, W. G. Hulbert, J. de N. Macomb, J. C. Mock, A. J. Neafie, G. A. Peabody, O. C. Rehfuss, E. M. T. Ryder, G. J. Slibeck, Theo. Speiden, Jr., C. R. Strattman, J. B. Strong, T. P. Warren, H. N. West.

The Committee presents Plans Nos. 987 and 988 showing Connected Straight Tongue Switches for Main Line Use and Industrial Tracks, 7″ and 9″ Girder Rails, for use with 4′ 8½″ Gage Through Turnout, as referred to in note on Plan No. 980.

These plans are presented as information to invite criticism.

Conclusions

The Committee recommends that the following plans submitted herewith be received as information:

Plan No. 987, dated November 1931, A.R.E.A. Straight Double Tongue Switches for engine wheel base not over 14′-6″—Solid Manganese Steel—For Use in Paved Streets, 7″ and 9″ Girder Rails.

Plan No. 988, dated November 1931, A.R.E.A. Straight Double Tongue Switches for engine wheel base over 14′-6″ but not exceeding 19′-0″—Solid Manganese Steel—For Use in Paved Streets, 7″ and 9″ Girder Rails.

The Committee recommends that this subject be continued.

Appendix G

(6) CORROSION OF RAILS AND FASTENINGS IN TUNNELS

C. J. Geyer, Chairman, Sub-Committee; C. R. Harding, H. G. Aberg, W. H. Bettis, L. H. Bond, R. W. E. Bowler, C. W. Breed, J. J. Desmond, J. H. Dymock, W. J. Harris, F. W. Hillman, E. T. Howson, H. D. Knecht, J. de N. Macomb, F. H. Masters, C. M. McVay, G. H. Pegram, O. C. Rehfuss, I. H. Schram, Theo. Speiden, Jr.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year, and it is recommended that the subject be continued.

Appendix H

(7) GAGE OF TRACK AND ELEVATION OF CURVES, WITH REFERENCE TO THE USE OF ROLLER BEARINGS ON RAILWAY EQUIPMENT

C. W. Breed, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. H. Bettis, L. H. Bond, F. S. Hales, W. J. Harris, F. W. Hillman, J. E. Hogan, E. T. Howson, C. R. Strattman, E. D. Swift.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year, and it is recommended that the subject be continued.

Appendix I

(8) EFFECT OF EXISTING MATERIALS IN TRACK ON THE DESIGN OF TIE PLATES AND PUNCHING THEREOF, TOGETHER WITH THE INTERRELATION OF SLOTTING OF JOINT BARS AND SIZE OF TRACK SPIKES

J. de N. Macomb, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, W. G. Arn, W. H. Bevan, R. W. E. Bowler, W. G. Brown, E. W. Caruthers, H. R. Clarke, J. W. DeMoyer, L. W. Deslauriers, J. A. Ellis, W. J. Harris, O. F. Harting, F. W. Hillman, F. J. Jerome, H. D. Knecht, F. H. Masters, J. B. Myers, A. J. Neafie, J. V. Neubert, C. J. Rist, W. L. Roller, I. H. Schram, G. L. G. Smith, Theo. Speiden, Jr., E. D. Swift, J. R. Watt.

The Committee reports progress. Information on this subject is not developed sufficiently to warrant a report this year, and it is recommended that the subject be continued.

Appendix J

(9) STANDARD WHEEL FLANGES, TREADS AND GAGES

J. V. Neubert, Chairman, Sub-Committee; C. R. Harding, C. J. Geyer, C. A. Alden, E. W. Caruthers, G. A. Peabody, J. B. Strong.

This subject has been under discussion for the past three or more years. Many joint conferences have been held between this Sub-Committee, representatives of the Mechanical Division of the A.R.A., and representatives of the Association of Manufacturers of Chilled Car Wheels. Measurements of the actual conditions that exist in track on certain railroads have been surveyed for both new and old wheel equipment, and for new and worn track conditions, from which composite diagrams have been prepared.

Among other data, field measurements disclosed frogs with flangeway 1⅝″ wide or less as follows:

In major track ....32 in 191 examples taken.
In secondary track ....69 in 142 examples taken.

Besides analyzing these field measurements, Mr. F. K. Vial, representing the Association of Manufacturers of Chilled Car Wheels, has prepared templets illustrative of the actual conditions encountered with the various tolerances. Mr. Vial has templets that he could present to demonstrate these comparisons to anyone interested.

Conclusions

The Committee recommends that the data relating to gages and flangeways through track at frogs and crossings shown on the following plan, submitted herewith, be adopted as recommended practice and printed in the Manual:

Plan No. 790, dated September, 1931, A.R.E.A. Data for Gages and Flangeways through Track at Frogs and Crossings, showing limits where Gage is not Widened for Curvature.

It is recommended also that this report be considered as final for the time being and that the subject be discontinued.

REPORT OF COMMITTEE XI—RECORDS AND ACCOUNTS

C. C. Haire, *Chairman;*
E. Y. Allen,
Anton Anderson,
R. R. L. Bullard,
E. S. Butler,
E. B. Crane,
W. F. Cummings
T. F. Darden,
V. H. Doyle,
C. J. Geyer,
J. H. Hande,
C. R. Harte,
H. M. Hockman,
Alfred Holmead,
A. T. Hopkins,
J. D. Hudson,
W. W. James,
W. R. Kettenring,
C. A. Knowles,
Henry Lehn,
W. T. Mead,
E. W. Metcalf,

B. A. Bertenshaw, *Vice-Chairman;*
W. S. McFetridge,
A. T. Powell,
J. T. Powers,
H. L. Restall,
H. L. Ripley,
Hans Schantl,
J. H. Schilling,
F. C. Sharood,
Chas. Silliman,
D. W. Smith,
G. H. Smith,
F. X. Soete,
J. Stephenson,
D. C. Teal,
F. W. Thompson,
G. R. Walsh,
J. W. Webster,
H. R. Westcott,
A. P. Weymouth,
Louis Wolf,
W. H. Woodbury,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

Group A—Miscellaneous:

(1) Revision of the Manual.—The Committee has continued its work of studying the Manual and Proceedings with a view of developing revisions of the material already in the Manual and to determine if certain reports in the Proceedings should be recommended for inclusion in the Manual. Much of the work of revising material in the Manual is being performed by various Sub-Committees in their studies of the Committee's assignment in the accounting and valuation fields. The Committee reports progress and will endeavor to present next year detailed recommendations that will necessarily come about because of the issuance of the Depreciation Order and the new Classifications.

(2) Bibliography on subjects pertaining to Records and Accounts (Appendix A).

Group B—General Railway Engineering Reports and Records:

(1) Drawings and drafting room practices (Appendix B).

(2) Methods and forms:

(a) For maintaining a record of railway, highway and private grade crossings collaborating with Committee IX—Grade Crossings.

(b) For making annual reports of grade crossings added or eliminated, collaborating with Committee IX—Grade Crossings (Appendix C).

(3) Bridge inspection report forms, collaborating with Committee VII—Wooden Bridges and Trestles, VIII—Masonry, XII—Rules and Organization and XV—Iron and Steel Structures (Appendix D).

Group C—Maintenance of Way Reports and Records:

(1) Statistical requirements of operating, accounting and other departments with respect to maintenance of way and structures, collaborating with appropriate committees (Appendix E).

Bulletin 344, February, 1932.

(2) System of reports and records required to budget and control maintenance of way expenses.—This being a new subject, the Committee can report only progress this year. Data has been collected from a considerable number of railroads in regard to methods and forms used in controlling maintenance of way expenses, but in view of the probable effect of the Depreciation Order of the Interstate Commerce Commission, and due to the possibility of a new Classification of Accounts being issued in the near future, it is the opinion of the Committee that the effect of depreciation accounting will be so radical that no report should be made this year.

(3) Forms used by railway water service departments, collaborating with Committee XIII—Water Service and Sanitation (Appendix F).

Group E—Valuation:

(1) Methods and forms for gathering the data for keeping up to date the valuation and other records of the property of railways, with respect to:

(a) Changes made necessary by government regulations.
(b) Simplicity and practicability of use (Appendix G).

(2) Methods and forms for maintaining a record of changes in jointly owned interlocking plants, with respect to ownership and contract provisions, collaborating with Committee X—Signals and Interlocking (Appendix H).

(3) Methods used in recapture proceedings (Appendix I).

Group F—Accounting Practices Affecting Railway Engineering:

(1) Changes or revisions in I.C.C. Classification of Accounts.—The Committee has nothing to report this year as there has not been published to date any proposed drafts of new classifications that are pending. It is understood that the Bureau of Accounts, Interstate Commerce Commission, will soon issue an entire new set of classifications that will harmonize with the Depreciation Order that was issued July 28, 1931.

(2) Methods and forms for handling the I.C.C.'s requirements under Order No. 15100—Depreciation Charges of Steam Railway Companies (Appendix J).

(3) Methods for avoiding duplication of effort and for simplifying and co-ordinating work under the requirements of the Interstate Commerce Commission with respect to accounting, valuation and depreciation (Appendix K).

(4) Recommended practice to be followed in preparing data for rate and other cases with respect to valuations, allocation of operating and maintenance costs to various zones and allocation of costs to specific services performed.—The Committee can only report progress on this subject.

Action Recommended

(1) That the reports on subjects A-1, C-1, C-2, F-1 and F-4 be received as information and the subjects continued.

(2) That the reports on subjects A-2, B-1, B-3, C-3, E-1, E-3, F-2 and F-3 be received as progress reports and the subjects continued.

(3) That the report on subjects B-2 and E-2 be received as information and the subjects discontinued.

THE COMMITTEE ON RECORDS AND ACCOUNTS,
C. C. HAIRE, *Chairman*.

Respectfully submitted,

Appendix A

(A-2) BIBLIOGRAPHY ON SUBJECTS PERTAINING TO RECORDS AND ACCOUNTS, APPEARING IN CURRENT PERIODICALS

W. T. Mead, Chairman, Sub-Committee; E. B. Crane, C. R. Harte, Alfred Holmead, H. R. Westcott, W. H. Woodbury.

The method followed in compiling this bibliography was the same as used last year. Each member of the Sub-Committee was assigned to watch certain periodicals and report his findings. The several reports were then combined.

BIBLIOGRAPHY

Valuation

Books

Rails and Roads, published by Association of Railway Executives, Washington, D.C. (Apply).

Railroad Regulation since 1920–1931, supplement by Philip D. Locklin (McGraw Hill Book Company).

The Accountants' Encyclopedia, Vol. IV, by Bruere and Lazarus, contains in Chapter III a discussion of the budget system as applied to railroads. Treats budgeting capital expenditures, maintenance of way and equipment expenditures, control of material, forecasting cash requirements, traffic trends and transportation expenses and making the budget a vital part of the organization (McGraw Hill Book Company).

Life Characteristics of Physical Property, Bulletin 103, by Robley Winfrey and Edwin B. Kurtz, Iowa State College of Agriculture and Mechanical Arts, Ames, Iowa.

Periodicals

Considerable litigation inevitable over valuation and recapture cases. News items and excerpts from briefs, Jonesboro, Lake City & Eastern and Duluth, Missabe & Northern. Traffic World, Sept. 6, 1930, p. 594.

Recapture arguments in Richmond, Fredericksburg & Potomac Ry. Case. Brief statement of some of the points made. Traffic World, Oct. 11, 1930, p. 872.

Commissioner Eastman discusses regulation and valuation. Traffic World, October 25, 1930, p. 1021.

Statement of recapture payments by carriers, 1920 to 1929 inclusive. Traffic World, November 1, 1930, p. 1079.

C. D. Morris, of Western Railways Committee on Public Relations, in an address, stated that he is opposed to revision of Sec. 15 (a) I.C.C. Act. Traffic World, March 7, 1931, p. 590.

Final Recapture decision on the Richmond, Fredericksburg & Potomac Ry. Co. Traffic World, April 25, 1931, p. 1009.

Former Commissioner Woodlock comments on R.F.&P. decision. Traffic World, May 2, 1931, p. 1063.

Total railroad valuations brought to date for use in 15 per cent rate increase hearing. Traffic World, July 11, 1931, p. 73.

Richmond, Fredericksburg and Potomac advised by Comptroller M. Carl that government will pay no money for hauling mail, passengers and freight until the railroad pays the recapture amount assessed by the I.C.C. Traffic World, August 8, 1931, p. 272; August 15, 1931, p. 325.

Rate Arguments before the I.C.C. Refers to valuation figures introduced by I.C.C. Railway Age, September 26, 1931.

Discussion of recapture clauses, by S. T. Bledsoe. Railway Age, September 26, 1931.

Discussion of Rates, Wages, Consolidation, by Daniel Willard. Railway Age, September 26, 1931.

Accounting

Norfolk & Western protests accounting order by I.C.C. regarding coal mines owned by the railroad company. Traffic World, June 13, 1931, p. 1422.

Centralized Machine Accounting for Better Records, by J. C. Wallace. Railway Age, August 8, p. 199.

Editorial on the Depreciation Order. Railway Age, September 26, 1931.

Maintenance

Machines in Maintenance Work: Power tie adzers, laying rail with small crane, power tampers, screw spike drivers, bolt tighteners, pneumatic drill for lag screws, chain link saws, spray painting, Railway Age, September 19th, 1931, p. 428.

Appendix B

(B-1) DRAWINGS AND DRAFTING ROOM PRACTICES

G. R. Walsh, Chairman, Sub-Committee; R. R. L. Bullard, V. H. Doyle, H. M. Hockman, J. D. Hudson, C. A. Knowles, J. H. Schilling, D. C. Teal, F. W. Thompson, J. W. Webster.

This is a new subject. The Committee reports progress and as information outlines a plan of procedure on its assignment. Tentatively, the assignment has been subdivided into fourteen (14) topics. It appears preferable to take each topic up separately as in that way definite progress is made and the Association may review the work as each topic is developed:

1. Classification of and corresponding nomenclature for drawings in accordance with their purpose.
2. Method of representation of the subject, including arrangement of views and sections.
3. Use of lines of different kinds and thickness.
4. Indication of dimensions, tolerances, and fits, tapers and slopes, and surface or finish.
5. Symbols for elements.
6. Indication of materials by cross hatching.
7. Arrangement of border line, title, parts list, notes, changes and revisions.
8. Method of folding and punching.
9. Kinds and sizes of lettering, figures and symbols.
10. Scales of reduction and enlargement.
11. Sizes of drawings and filing cabinets.
12. Width of rolls of paper and cloth.
13. Size of drafting equipment and tools.
14. Specifications of materials to be used for drawings and drafting.

Recommendation

That the subject be continued.

Appendix C

(B-2) METHODS AND FORMS

(a) For Maintaining a Record of Railway, Highway and Private Grade Crossings, Collaborating with Committee IX—Grade Crossings

(b) For Making Annual Reports of Grade Crossings Added or Eliminated, Collaborating with Committee IX—Grade Crossings

W. W. James, Chairman, Sub-Committee; Anton Anderson, R. R. L. Bullard, E. S. Butler, E. B. Crane, C. R. Harte, W. S. McFetridge, J. H. Schilling, F. X. Soete, G. H. Smith, D. C. Teal.

These subjects were continued from last year. Inquiries from railways operating in some forty States indicate that practically no State requires annual reports other than those reported to State Commissions, showing the same information that is reported annually to the Interstate Commerce Commission on Form 510.

According to report of the National Association of Railroad and Utilities Commissioners, dated 1930, there is a steady net increase in the number of grade crossings, highways with railways; the report shows the net increase to be:

1926.....195 1927.....245 1928.....270 1929.....321

This report also shows that as of December 31, 1929, there were 242,809 highway grade crossings on Class I railways.

It is the Committee's hope that the forms recommended in this report will aid in simplifying the work of collecting and reporting essential information rather than adding to it.

Exhibit 1 is a form for making annual reports of highway grade crossings added and eliminated. It provides only for the most essential information. It is designed to show the number of the various classes of highways crossing railways at grade at the beginning and at the end of each calendar year and the changes made during the year. Section (B) covers the requirements of the Interstate Commerce Commission and Section (C) covers the requirements of the Bureau of Railway Economics. (Recommended size of form 8½″ × 11″.)

Exhibit 2 is a form for recording data with reference to individual highway grade crossings and furnishes the underlying information with which to compile Exhibit 1. (Recommended size of form 8½″ × 11″.)

Exhibit 3 is a form designed for the purpose of recording the information (with certain changes approved by Committee IX) called for in Committee IX's report set forth in Vol. 32 of the Proceedings, page 84, as Appendix D It is recommended that this form be used only in connection with special investigations.

The Committee has collaborated freely with Committee IX—Grade Crossings, both in the design of the above forms and in the design of the forms included in Committee IX's report.

Recommendation

The Committee recommends that the forms be adopted and printed in the Manual.

Exhibit 1

Date ....

NORTH AND SOUTH RAILROAD

OFFICE OF CHIEF ENGINEER

Form No. ....

Northland, N.P.

ANNUAL REPORT OF HIGHWAY GRADE CROSSINGS

FOR .... FOR YEAR..............

(System, Division, State or other subdivision)

DESCRIPTION	Number at Begin'g of Year	Number Added During Year	Number Eliminated During Year	Number at End of Year	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
(A) TOTAL NUMBER OF GRADE CROSSINGS					
Class of highway					
1. F. A. P.—Federal aid—Primary					
2. F. A. S.—Federal aid—Secondary					
3. O. S.—Other state highway					
4. L. R.—Local Road					
5. Street—Street within limits of incorporated city, not maintained by state highway commission					
(B) INTERSTATE COMMERCE COMMISSION REQUIREMENTS					
Kind of Protection					
1. Gates, with or without other protection, operated 24 hours per day					
2. Gates, with or without other protection, operated less than 24 hours per day					
3. Watchmen, alone or with protection other than gates, on duty 24 hours per day					
4. Watchmen, alone or with protection other than gates on duty less than 24 hours per day					
5. Both audible and visible signals without other protection					
6. Audible signals only					
7. Visible signals only					
8. Special fixed signs or barriers with or without standard fixed signs					
9. Standard fixed signs					
10. Otherwise unprotected					
11. Total					
(C) BUREAU OF RAILWAY ECONOMICS REQUIREMENTS—FORMS ES					Gross Expenditures during year.
1. Separation of grade					
2. Automatic warning devices, gates, signals and signs (a) New installation					
(b) Improvement to old					
3. Abandonment or removal					

Exhibit 2

Form No. ....

NORTH AND SOUTH RAILROAD

OFFICE OF CHIEF ENGINEER Date ....

Northland, N.P.

INDIVIDUAL HIGHWAY GRADE CROSSING DATA

DIVISION ....BRANCH ....MILEPOST ....

MUNICIPALITY ....COUNTY ....STATE ....

Detail information called for on this form is intended for use in compiling data for "Annual Report of Highway Grade Crossings." (See Exhibit 1)

DESCRIPTION	At Begin'g of Year	At End of Year	Remarks
(1)	(2)	(3)	(4)
(A) CLASS OF HIGHWAY			
1. F. A. P. —Federal aid—Primary			
2. F. A. S. —Federal aid—Secondary			
3. O. S. —Other state highway			
4. L. R. —Local road			
5. Street—Street within limits of incorporated city, not maintained by state highway commission			
(B) INTERSTATE COMMERCE COMMISSION REQUIREMENTS Kind of Protection			
1. Gates, with or without other protection, operated 24 hours per day			
2. Gates, with or without other protection, operated less than 24 hours per day			
3. Watchmen, alone or with protection other than gates, on duty 24 hours per day			
4. Watchmen, alone or with protection other than gates on duty less than 24 hours per day			
5. Both audible and visible signals without other protection			
6. Audible signals only			
7. Visible signals only			
8. Special fixed signs or barriers with or without standard fixed signs			
9. Standard fixed signs			
10. Otherwise unprotected			
11. Total			
(C) BUREAU OF RAILWAY ECONOMICS REQUIREMENTS—FORMS ES 2-5-6	Installed Date	In Progress Date	Gross Cost
1. Separation of grade			
2. Automatic warning devices, gates, signals, and signs			
(a) New installation			
(b) Improvement to old			
3. Abandonment or renewal			

Form No......... NORTH AND SOUTH RAILROAD Exhibit 3

OFFICE OF CHIEF ENGINEER

Northland, N.P.

INDIVIDUAL HIGHWAY GRADE CROSSING DATA (Special)

Date................

DIVISION............................ BRANCH.......................................

MUNICIPALITY.................. COUNTY.................. STATE...................

Note.—Information should be obtained by field inspection and from records. It should be compiled on ground in tabular form which should be filled out, dated and certified as correct by the Engineer making the inspection.

1. Milepost and hundredths................ If new—Date Installed................
2. *Class of highway, local road or street..
3. U. S. number of highway or street..
4. State number of highway or street..
5. Name of highway, road or street...
6. Number of street car tracks...
7. Number of main tracks crossed...
8. Number of side and/or spur tracks crossed.....................................
9. Tracks of other Railroads..
10. Approximate angle of crossing..
11. Character of highway alinement for 1000 feet each side of crossing...............
12. *Kind of surface of highway, road or street, approaching the crossing:............ ....
13. Width of surface of highway, road or street, within 500 feet each side of crossing: ....
14. *Kind of surface of crossing:..
15. Length of surface of crossing, measured along center line of railroad ....
16. *Visibility: ....
17. *Approach highway grades (state whether ascending or descending)...............
18. Maximum speed of passenger trains (m.p.h.)...................................
19. Maximum speed of freight trains (m.p.h.).......................................
20. Number of passenger trains per day (24 hours) (average for one month).........
21. Number of freight trains per day (24 hours) (average for one month)............
22. Number of switching movements per day (24 hours) (average for one month)....
23. Highway traffic per day (24 hours) Show number from representative traffic count ....
24. *Is kind of protection...
25. *Is elimination of grade crossing feasible...
26. What percentage of highway traffic can be diverted by relocation................
27. Total accidents at crossing for a period of past five years.......................
28. File Reference ....

Note.—If this grade crossing is eliminated enter following data.

A.F.E. No.......... Date..................... Method..........................

---

* For explanatory notes, see back of sheet.

EXPLANATORY NOTES

(To be printed on the back of Exhibit 3)

(2) *Abbreviation* — *Class*

F.A.P. .... Federal Aid—Primary
F.A.S. .... Federal Aid—Secondary
O.R. .... Other Roads—State or County
L.R. .... Local Road
Street .... Street within limits of incorporated city, not maintained by state highway commission.

(12) (a) Concrete or brick.
(b) Bituminous macadam or bituminous concrete.
(c) Waterbound macadam, gravel, etc.
(d) Earth.

(14) (a) Metal, or metal and concrete.
(b) Stone, concrete or brick.
(c) Bituminous.
(d) Crushed stone, gravel or slag.
(e) Plank (Wood).
(f) Plank (Concrete, bituminous, etc.).
(g) Patented materials.
(h) Earth.

(16) (a) "Good"—Train or locomotive visible for at least one thousand feet each way along track from approaching vehicle within a distance of two hundred feet either way from crossing.
(b) "Fair"—Train or locomotive visible for at least one thousand feet each way along track from approaching vehicle within a distance of one hundred feet either way from crossing.
(c) "Restricted"—Other conditions.

(17) (a) "Easy"—Approximately level for 10 to 20 feet and thence not over 5 per cent.
(b) "Medium"—Approximately level for 10 to 20 feet and thence 5 per cent to 10 per cent.
(c) "Steep"—Approximately level for 10 to 20 feet and thence over 10 per cent.

(24) (a) Gates, with or without other protection, operated 24 hours per day.
(b) Gates, with or without other protection, operated less than 24 hours per day.
(c) Watchmen, alone or with protection other than gates, on duty 24 hours per day.
(d) Watchmen, alone or with protection other than gates, on duty less than 24 hours per day.
(e) Both audible and visible signals, without other protection.
(f) Audible signals only.
(g) Visible signals only.
(h) Special fixed signs or barriers, with or without standard fixed signs.
(i) Standard fixed signs only.
(j) Approach signs.
(k) Otherwise unprotected.

(25) (a) By relocation of highway—considering topography, property values and adjacent improvements at reasonable cost.
(b) By separation of grade—considering topography, drainage, adjacent improvements and possible change in grade of highway or railroad at reasonable cost.
(c) By vacation or closing and diversion of traffic to other crossing or crossings, considering the character and density of highway traffic and extent of inconvenience thereto.

Appendix D

(B-3) BRIDGE INSPECTION REPORT FORMS, COLLABORATING WITH COMMITTEES VII—WOODEN BRIDGES AND TRESTLES. VIII—MASONRY, XII—RULES AND ORGANIZATION, AND XV—IRON AND STEEL STRUCTURES

W. T. Mead, Chairman, Sub-Committee; C. C. Haire, J. D. Hudson, D. W. Smith, G. R. Walsh, Louis Wolf.

This subject has been before the Committee for three years, and in 1930, after investigating the various practices followed by railroads, three (3) forms were prepared by the Committee and presented to the Association. These forms, and the report, are found in Vol. 32 of the Proceedings, pages 537, 538, 539, 540 and 541, and when the forms were presented the statement was made that collaboration with other committees had not been completed.

There are four committees that have been instructed to collaborate with Committee XI, and it has been difficult to secure a unanimity of opinion as to the exact design of these forms. Committee VII—Wooden Bridges and Trestles, and Committee XV—Iron & Steel Structures, have approved the forms designed by Committee XI, whereas the other two prefer that the forms be left blank below the heading, so it is largely a matter of details that are shown on the forms that has prevented completion of the assignment with the entire approval of the four collaborating committees.

Owing to the difficulty of arriving at complete collaboration, involving so many interests, the Committee finds it necessary to recommend again that the subject be continued another year. It is the intention that the method of collaboration be organized on a basis that will insure completion of the assignment next year, which will be to form a sub-committee composed of a member from each collaborating committee, with full authority to act, and to instruct such a group to design forms that will be acceptable to the interests of the five committees.

Appendix E

(C-1) STATISTICAL REQUIREMENTS OF OPERATING, ACCOUNTING AND OTHER DEPARTMENTS WITH RESPECT TO MAINTENANCE OF WAY AND STRUCTURES, COLLABORATING WITH APPROPRIATE COMMITTEES

W. F. Cummings, Chairman, Sub-Committee; Anton Anderson, W. S. McFetridge, Hans Schantl, G. H. Smith, F. X. Soete, H. R. Westcott, A. P. Weymouth.

The work of this Sub-Committee is in continuation of previous reports briefly summarized on page 896, Vol. 31 of the Proceedings. As the statistical requirements of the several departments must be met by periodic reports originating in the field, the Committee has gone forward to the next step in the series of reports outlined on the chart on page 278 of Vol. 27 of the Proceedings and considered the statistical requirements covering work equipment and special machines operations. These requirements are distinct from those governing the reporting of revenue equipment.

The assignment of the subject last year and this year differs from that of 1929 in the respect that it does not direct the Committee specifically to recommend reports but provides for collaboration with appropriate committees. This revision of subject assignment was coincident with the formation of a Special Committee on Maintenance of Way Equipment to which was assigned the subject, "Methods of keeping data on

work equipment and labor-saving devices," a transfer of assignment from Sub-Committee 10 of Committee XXII—Economics of Railway Labor.

Work Equipment and Special Machines Operations

In collaboration with the Special Committee, this Committee has studied the forms presented as information by the Committee on Economics of Railway Labor shown as Exhibits A and B on pages 1292–1294 in Vol. 31 of the Proceedings, in the light of the statistical requirements of the several departments and the specifications in the Manual for the design, arrangement and printing of forms.

The term "work equipment" is intended to include special purpose rolling equipment regularly assigned to the Maintenance of Way and Structures Department, all special machines and labor-saving devices.

Statistical Requirements of the Division Engineer

It is essential that the Division Engineer be equipped with sufficient data as to the performance of work equipment that he can control their use and efficiency, maintain unit-cost records and compare the economies of their use with other methods. These requirements may be outlined:

(a) All work equipment and special machines to be numbered for identification in reports.
(b) A continuous record of each piece of equipment by daily report whether work performed, idle or in transit between jobs.
(c) Project on which worked and location.
(d) Number of units of work performed.
(e) Time and rate of labor operating the equipment.
(f) Time lost and cause of delays.
(g) Material and labor on repairs to equipment.
(h) Fuel and supplies used.
(i) Name and title of operator or foreman and designation of supervisor's district.

Statistical Requirements of the Engineer Maintenance of Way

The major purposes of equipment reports to the Engineer Maintenance of Way are: a consolidated record of all equipment, correction of inefficient practices, control of (a) distribution, (b) economical use, and (c) repairs, and for comparison of results on divisions and with other methods.

Reports to meet these requirements should be compiled in the Division Engineer's office from the daily reports received from the operator or foreman and forwarded to the Engineer Maintenance of Way weekly. These reports should be consolidated as to time but show substantially the same items for individual pieces of equipment as shown on the daily reports to the Division Engineer.

Statistical Requirements of the Accounting Department

The Accounting Department requires information to enable it to apply charges for the use of work equipment to Authority for Expenditure projects under appropriate primary and sub-accounts, and to bill against other parties such as for ordinary recollectible work, work in joint facility territory and work in connection with grade crossing elimination. Accounting adjustments are often necessary and it is therefore important, in order to avoid accounting delays and expense, that all use of work equipment on Authority for Expenditure projects and projects involving recollectible features be reported.

These reports should be compiled in the Division Engineer's office from the basic information on the Operator's or Foreman's daily reports with additional identification of the class of work and forwarded to the Accounting Department on monthly forms, showing the following data:

(a) Title and number of project.
(b) Number and type of work equipment.
(c) Reference to labor time returns.
(d) Dates work equipment used.
(e) Total time work equipment used, including chargeable idle time and time in transit.
(f) Miles work equipment carried in revenue trains.
(g) Appropriate chargeable labor and material on repairs to equipment.
(h) Fuel and supplies used.
(i) Primary accounts to which chargeable.
(j) Sub-accounts to which chargeable.
(k) Valuation section.
(l) Columns for extension of prices by the Accounting Department.
(m) Identification of report by number.

Charges for the use of work equipment shall include interest on investment, taxes and depreciation as determined by the Accounting Department.

Conclusions

The report is presented as information and the Committee recommends that the subject be continued.

Appendix F

(C-3) FORMS USED BY RAILWAY WATER SERVICE DEPARTMENTS, COLLABORATING WITH COMMITTEE XIII—WATER SERVICE AND SANITATION

D. C. Teal, Chairman, Sub-Committee; R. R. L. Bullard, E. B. Crane, E. W. Metcalf, Hans Schantl, D. W. Smith.

The subject is a continuation of the assignment made two years ago. Last year's progress report is given on page 523, Vol. 32 of the Proceedings.

The study of forms now in common use by railway water service departments resulted in the following general classification of reports and records.

(1) Monthly and yearly report of cost of producing and treating water.
(2) Pumper's and treating plant operator's reports.
(3) Water station record.
(4) Geological record of deep wells.

The first of the above list was selected as the most important report and a form designed to record the cost of producing and treating water. This form was presented to the Association last year, recommended as the permanent "Cost of Water Production" record, suitable for present-day water service requirements, to be kept in the division or system headquarters of officer in charge of water supply.

This year the Sub-Committee has taken up the study of the second general class of reports. Consideration was first given to the possibility of combining the pumper's report of water station operation with the water treatment report. Further investigation however proved that such a form would be inefficient, unwieldy and unsatisfactory as some railroads have no water treating plants at all and others have but relatively few of their water stations equipped with treating facilities.

With the idea in mind that most railroads prefer to handle their water production entirely separate from water treatment, the Sub-Committee has developed a form for the pumper's report of water station operation. This form is presented herewith as Exhibit 1, with the understanding that a separate form for recording and reporting water treatment is to be designed and presented at a later date.

Exhibit No 1
Form 1301-Revised
Recommended Size 11" x 21½"

The North And South Railroad
Monthly Report Of Water Station Operation

_______________ Station
_______________ Division.
Month of __________ 19____

Source Of Water Supply ____________ Type Of Station ______________

Pump Operation and Water Consumption

Day of Month	Hours-Operation No. 1 Unit	Hours-Operation No 2 Unit	Water Produced "M" Gallon	Number of Engines Watered	Used by Engines "M" Gallon	Used for Other Purposes "M" Gallon
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
Totals						

Supplies Used During Month

Supply Item	Unit	On Hand First of Month	Received During Month	Total to Account For	On Hand End of Month	Amount Used During Month	Unit Price	Cost of Supplies for Month	Handling Charges
(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Coal	Tons								
Fuel Oil	Gal.								
Oil Engine Distillate	Gal.								
Gasoline	Gal								
Kerosene	Gal								
Cup Grease	Lbs								
Waste	Lbs								
Lubricating Oils	Quarts								
						Total for Month			

Meter Readings and Rentals

Service Item	Unit	Meter Reading at End of Current Month	Meter Reading at End of Previous Month	Amount Used	Unit Rental	Cost for Month	Name of Company Furnishing Service
(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
Water							
Electric Power							
Gas							

Operating Expenses of Plant

Name of Attendant	Hours Worked	Amount Earned	Incidentals	Cost of Incidentals	Remarks
(26)	(27)	(28)	(29)	(30)	(31)
Totals					

Instructions :- This Report To Be Prepared In Triplicate At End Of Each Month By Attendant In Charge Of Plant. Original And One Copy To Be Mailed To Supervisor Who Is To Fill In Additional Information Required And Forward Approved Original To Supt Water Supply
Columns 2 to 7 Inclusive To Be Posted Each Day By Attendant In Charge
Columns 10 to 14 And 20 to 22 To Be Posted By Attendant At End Of Month
Remaining Information To Be Furnished By Water Supply Supervisor

Signed :- ____________________
Attendant In Charge

Signed :- ____________________
Water Supply Supervisor

MONTHLY REPORT OF WATER STATION OPERATION

This form is designed for the daily recording and monthly reporting of water production and consumption and is to furnish the underlying information with which to compile the permanent "Cost of Water Production" record, as well as other information necessary for the close check of water station performance.

The recommended size of 11" × 21½" will give ample room for posting figures and data and will fold to letter-size sheets for mailing purposes. Instructions for routine of handling are given on the form.

The section of the report devoted to "Pump Operation and Water Consumption" provides the necessary information required for proper supervision of water supply, as well as data for posting the permanent cost record. The columns for recording "Supplies Used During Month" furnish a complete record of supplies used at the water station. This information is very necessary when ordering additional supplies for the plant and is also required for the permanent cost record. The "Meter Readings and Rentals" columns provide for complete information regarding any rented service facility that might be used. The rentals are of course required for posting permanent cost record. Operating expense of plant are also necessary for the permanent cost record.

This form supersedes Form 1301 now in the Manual and is believed to be adapted to present day water service uses.

Form No. 1301—Revised, is presented to the Association this year as information.

Appendix G

(E-1) METHODS AND FORMS FOR GATHERING THE DATA FOR KEEPING UP TO DATE THE VALUATION AND OTHER RECORDS OF THE PROPERTY OF RAILWAYS, WITH RESPECT TO:

(a) Changes made necessary by government regulations.

(b) Simplicity and practicability of use.

B. A. Bertenshaw, Chairman, Sub-Committee; E. Y. Allen, V. H. Doyle, Alfred Holmead, A. T. Hopkins, W. W. James, W. R. Kettenring, W. T. Mead, E. W. Metcalf, A. T. Powell, H. L. Restall, H. L. Ripley, James Stephenson, J. W. Webster, Louis Wolf, W. H. Woodbury.

(a) Forms

LIST OF SIDE TRACKS

Forms for "Record of Side Tracks" may be found in the Manual at page 717 and in the Proceedings, Vol. 27, at page 257, and Vol. 31 at page 871. The first two forms are materially different in character from the latter, inasmuch as they are intended to serve a different purpose. The form in the Manual and the one in the Proceedings, Vol. 27 at page 257, are intended to maintain only a "List of Side Tracks" by operating divisions with pertinent information as to ownership, length and location as regards counties, townships and corporations, while the form in the Proceedings, Vol. 31 at page 871, is a record of the units that go to make up the individual side track and the changes in these units as made from time to time. This latter form was designed to record the changes in the units so as to have the required information in convenient form for assembling in compliance with Valuation Order No. 3, 2nd Rev. Issue, and its Supplements.

There would seem to be no good reason why the same care should not be given to maintaining a record of side tracks as is given to keeping a record of main tracks and other physical assets of the Railroad Company. It is just as important to keep a record showing pertinent facts relating to a track, which record should be supplemental to the written contract, as it is to keep the records of titled property. There is, in addition, a continually increasing demand, on the part of local and national authorities, for data in connection with physical property lying within political subdivisions such as counties, townships, corporations and school districts, for which reliable records should be readily accessible. Reports must be made at stated intervals to State Railroad Commissions and to the Interstate Commerce Commission; data must be provided for annual reports; records of side tracks in taxing districts must be maintained in certain states and localities; and for operating purposes a record showing length and ownership of side tracks should always be available.

The form in the Manual at page 717 is not of the recognized standard size and calls for information that is seldom, if ever, used, while the form in the Proceedings, Vol. 27 at page 257, is not designed so as to conveniently assemble all of the necessary information. The Committee, therefore, submits a form, Exhibit 1, 11″ × 17″ in size, upon which is to be listed side tracks by operating divisions. This form will show the changes in length, the total length and the ownership of tracks by calendar years and will also show the number of feet of track in the taxing districts as of the date upon which the information for taxation purposes is required. The column heads indicate clearly the information to be recorded. This form will supersede the last two forms above mentioned, and its title, "List of Side Tracks", will distinguish the form and its

Exhibit 1

Class -
Y = Yard Tracks & Sidings
P = Passing Track
I = Industry Track
J = Jointly Owned Track

NORTH AND SOUTH R. R.
LIST OF SIDE TRACKS

State..........
Operating Division..........
Valuation Section..........

Line No.	TRACK			Contract Number	Period 12-31-..... to 12-31-.....				Tax Statement as of..........				Period 12-31-..... to 12-31-.....				Tax Statement as of..........				Line No.
	Number	Name	Class		Track Feet		Length		Track Feet in				Track Feet		Length		Track Feet In				
					Add	Ret	Total	Ry Owned	Township	Corporation	School District		Add	Ret	Total	Ry Owned	Township	Corporation	School District		
1		ST PAUL		DECATUR COUNTY					Adams	St Paul											1
2	13	Elevator	Y	1648	100		1638	240		240											2
3		Passing	P				4000	4000	4000		#106 4000										3
4		Canning	J	1701			600	Und ½	300	300											4
5																					5
6																					6
7																					7
8																					8
9																					9
10																					10
11																					11
12																					12
13																					13
14																					14
15																					15
16																					16
17																					17
18																					18
19																					19
20																					20
21																					21
22																					22
23																					23
24																					24

use from the one in the Proceedings, Vol. 31, page 871, the title of which is "Side Track Record".

Form Exhibit 2, size 11″ × 14″, is a continuation sheet for Exhibit 1, and has the binding margin on the left, while Exhibit 1 has the binding margin on the right; this readily permits of the following of lines from Exhibit 1 to Exhibit 2, when bound in book form. Exhibit 2 should be printed on both sides of the sheet and on the reverse side the binding margin should be on the right.

REGISTER OF AUTHORITIES FOR EXPENDITURES

Valuation Order No. 3, Second Revised Issue, requires that railroads maintain a "Register of Authorities for Expenditures". In the Manual at page 723 may be found a form for this purpose. However, this form is not of the recognized standard size and calls for information, which experience has shown is little used and is not required in the Order. The Committee accordingly has designed form Exhibit 3, "Register of Authority for Expenditures", 11″ × 17″ in size, which will collect all of the information in a simple, concise and legible form. The headings first looked for in searching for information in this connection, *i.e.*, A.F.E. number and the date, have been placed at the right of the form for the reason that when these forms are bound in book form their positions at the right of the page facilitate the finding of the particular authority being sought.

Exhibit 2
11″ x 14″

NORTH AND SOUTH R.R.
LIST OF SIDE TRACKS
CONTINUATION SHEET

Line No	Period 12-31- to 12-31				Tax Statement as of				Period 12-31- to 12-31-				Tax Statement as of				Line No
	Track Feet		Length		Track Feet In				Track Feet		Length		Track Feet in				
	Add	Ret	Total	Ry Owned	Township	Corporation	School District		Add	Ret	Total	Ry Owned	Township	Corporation	School District		
1																	1
2																	2
3																	3
4																	4
5																	5
6																	6
7																	7
8																	8
9																	9
10																	10
11																	11
12																	12
13																	13
14																	14
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16																	16
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18																	18
19																	19
20																	20
21																	21
22																	22
23																	23
24																	24

Exhibit 3
11"x17"

NORTH & SOUTH R.R.
REGISTER OF AUTHORITIES FOR EXPENDITURES

Page______

State	Vol Sec No	Location	Description of Work	ESTIMATED COST				Date	A F E No.
				Road & Equip.	Operating Expenses	Other Accounts	Total		

DETAILED ESTIMATE

Valuation Order No. 3, Second Revised Issue, also provides for detailed estimate sheets to accompany A.F.E.'s. A form "Detailed Estimate" may be found in the Proceedings, Vol. 29 at page 882. This form is subdivided into vertical columns and provides for the recording of information in a form that is neither flexible nor economical. The Committee has designed a form, Exhibit 4, for "Detailed Estimate", which is a sheet of standard size, $8\frac{1}{2}'' \times 11''$, without any column headings. This permits of great flexibility in the arrangement of the data and allows the use of practically the entire sheet for such purpose. On large projects where several sheets of "Detailed Estimate" are required, the last sheet only will bear the approval of the proper officials.

These forms, Exhibits 1 to 4 inclusive, are presented for information only.

Exhibit 4
8½"x 11"

NORTH & SOUTH R.R.
DETAILED ESTIMATE

Plan______________

Office______________

Location & Description

Vol.Sec.______________

Date______________

Sheet________of________

(b)-1 Simplification of method of recording changes on completion reports, record of property changes and B.V. form 588.

The Committee has made a study of possible economies that may be effected through the elimination of certain records or the substitution of some records for others as required under Valuation Order No. 3, Second Revised Issue, and its Supplements.

There are certain requirements in this Order and its Supplements that have proved particularly burdensome to the railroads where records have been made and kept in strict compliance with the Order, and it is to these features that the Committee wishes to call attention and to suggest methods of procedure which will effect economies in the preparation of the various records.

Section 6 of Supplement No. 5 to Valuation Order No. 3, Second Revised Issue, requires that retirements shall be subdivided to show separately property retired that was included in the basic valuation and property retired that has been installed subsequent to the date of inventory and included in the reports as provided in Valuation Order No. 3.

Section 7 of this Supplement further provides that the cost of such property retired as was included in the basic valuation shall be the aggregate cost of the construction and improvements of the property retired, and that the cost of such property retired as was installed subsequent to the date of valuation shall be the cost recorded in the Valuation Order No. 3 records covering the construction and improvement of that property. This Section further provides, "With respect to costs to be reported for retirements in connection with betterments applied, the above requirements may be limited to consequential items, such as those under primary accounts 6, Bridges, Trestles and Culverts; 9, Rails; 10, Other Track Material; 11, Ballast; and to substantial items under equipment and other accounts".

Those charged with carrying out the provisions of the Order have found it very tedious and difficult to comply with the above requirements in identifying property in the so-called mass accounts as between that installed prior to and subsequent to the basic valuation date, and even after such identification has been made it is still quite a task to determine the costs to be applied as required. This is particularly true of the numerous items that go to make up Account 10—"Other Track Material", and the Committee believes that the amount of work and the expense involved in complying with the above requirements for this account is out of all proportion to the relative importance of the account and that some relief might very well be extended without doing material injury to the result to be attained.

There are certain subschedules required in Supplement No. 5 that may be prepared at the same time as and made a part of the Completion Report, such as Subschedules L, M and X. This has the advantage of keeping current certain parts of B.V. Form 588 and will also eliminate the necessity of transcribing the same information in two or more sets of records, since these subschedules under this scheme would serve for Completion Report, Record of Property Changes and B.V. Form 588.

There may be considerable economy in the elimination of semi-annual Equipment Completion Reports except for a single summary sheet where underlying records are kept in such a manner as to have readily available all of the required information and such underlying records are made a part of the summary completion report.

There will be a saving if the weights of the various items in Account 10—"Other Track Material", are shown on the Roadway Completion Report in addition to the units as prescribed in Supplement No. 4 to Valuation Order No. 3. This will be true where the units on B.V. Form 588 for this account are reduced to hundred-weight since it facilitates the transcribing and collecting into hundred-weight from the underlying records to the B.V. Form 588.

It is understood that any of the methods suggested above, which are at variance with the literal requirements of the Order, should receive the approval of the Bureau of Valuation, Interstate Commerce Commission before being put into effect.

(b)-2 Simplified method of reporting Account 10—Other Track Material

This subject was continued from last year and, as stated in last year's Committee report, a study has been made with a view to finding some short and simple method of handling the numerous items in Account No. 10—"Other Track Material," which would produce results sufficiently accurate for all practical purposes, and at the same time eliminate, insofar as possible, the mass of minute detail involved in recording and reporting the changes in this account.

The following methods have been suggested and given study:

1. Method recommended in memorandum submitted by Presidents' Conference Committee, Circular Communication No. 1504–Ch., dated September 28, 1928.
2. Typing of Track by classes and weights of material.
3. Use of single unit price for retirements—weighted average price per cwt. for all new material.
4. Use of two unit prices for retirements—one, a weighted average price per cwt., for all new frog and switch material, and a second unit price for all other new material in the account.
5. Use of three unit prices for retirements—one, a weighted average price per cwt., for all material of alloy steel, a second unit price for all new frog and switch material of ordinary rail section and a third unit price for all other material in the account.
6. The equivalent weight method, i. e., reducing all items to equivalent cwt., using as a base the cost of some relatively staple item, such as spikes, applying to the other items the ratio of their cost to that of the base, as of any given period. Having thus established the equivalent cwt., costs may be translated to any other period by merely multiplying accumulated equivalent cwt. by the new unit price of the base on the assumption that the equivalent cwt. ratio remains constant.

Conclusions

The tests of the above methods have shown that, due to the wide variation of the kinds of track materials, the number of turnouts and the ratio or relation of side tracks and main tracks on a valuation section, or on an entire road, may make the use of one of the above methods desirable in one location but produce results widely variant from the actual in another. It is the conclusion of the Committee that if a railroad is desirous of using any of the methods outlined above, other than No. 1, it should make sufficient tests to prove conclusively that the results will be sufficiently accurate for all purposes and then secure permission from the Bureau of Valuation, Interstate Commerce Commission, for its adoption.

Appendix H

(E-2) METHODS AND FORMS FOR MAINTAINING A RECORD OF CHANGES IN JOINTLY OWNED INTERLOCKING PLANTS WITH RESPECT TO OWNERSHIP AND CONTRACT PROVISIONS, COLLABORATING WITH COMMITTEE X—SIGNALS AND INTERLOCKING

A. P. Weymouth, Chairman, Sub-Committee; A. Anderson, B. A. Bertenshaw, R. R. L. Bullard, E. S. Butler, W. S. McFetridge, J. T. Powers, Chas. Silliman.

This subject was assigned last year, and the Committee submitted a progress report which may be found on page 526 of the 1931 Proceedings, Vol. 32.

The Committee has continued its study of the subject this year, collaborating with Committee X—Signals and Interlocking.

As brought out in last year's report, existing contracts must, of course, be respected in matters of ownership, and new contracts will be a matter of agreement between interested parties. Unless, however, the contract provides specifically and in detail for joint participation in all additions and retirements to such interlocking plants, disputes will likely arise as to the percentages of ownership in the changed facility for various periods.

The Committee desires again to emphasize the necessity for accurately defining in every contract or agreement for jointly owned interlocking plants, the original division of ownership and the proper participation in joint ownership resulting from changes in the facility.

Of the methods that may be followed to determine the changing percentages of ownership due to alterations by one or more carriers in joint plants, the Committee feels that the "investment basis" is preferable. A record should be kept whereby the actual cost, if ascertainable, of the original construction of the joint plant is recorded, with the equity assigned to each carrier as of date of valuation; this record to be continued as changes, either additions or retirements, are made. Such a record could easily be compiled, and kept up to date, starting with the original costs, or an agreed estimate for joint facility purposes, and entering the A.F.E. changes as they occur, and as reflected by collection bills of the interested carriers.

It may be of advantage to have the detail record set up so as to separate the buildings and the interlocking plant proper, in order that the changes for each may be recorded independently of each other, thereby maintaining separately the ownership by the investment method. The ownership in the buildings generally does not change with revision of the interlocking plant, and each carrier's equity in such buildings would change only with additions or retirements pertaining to the building itself.

The Committee has prepared a form, Exhibit 1, which is herewith submitted as a part of this report, to serve as a guide in maintaining the record suggested above, in order to determine the varying percentages of ownership from year to year as changes are made in such joint facilities. To properly keep up such a record, the interested carriers should exchange copies of their respective Completion Reports and collection bills covering the additions or retirements to the joint plants affected.

The investment basis as a method for establishing ownerships appears to be logical, and in accord with other practices. It is furthermore supported by the recommended form of agreement for interlocking plants published in the A.R.E.A. Manual, 1929 Issue, page 1342, which states:

> "Each party hereto shall participate in the ownership of said interlocking plant in the ratio which the payments made by it for construction of said interlocking plant, including extensions and changes chargeable to Capital Account, bear to the total cost of construction thereof."

The collaborating committee (Committee X—Signals and Interlocking), has indicated its approval of the foregoing report.

Conclusion

The Committee recommends that the report be accepted as information, and the subject be discontinued.

Exhibit 1

8½″ × 11″

FORM FOR MAINTAINING RECORD OF OWNERSHIP IN JOINT INTERLOCKING PLANTS

Form No. ....

NORTH AND SOUTH RAILROAD

Office of .... Date ....

Location .... (Station) ....(State) ....(Division) ....(Val. Sec.)

Date	Road A. F. E.	Description	Cost Added	Cost Retired	Total Cost to Date	Division of Cost and Ownership: N. & S. R. R. %	N. & S. R. R. Amount	E. & W. R. R. %	E. & W. R. R. Amount	Total %	Total Amount
1915		Agreed Equity—Original Cost			$50,000	50	$25,000	50	$25,000	100	$50,000
1920	N & S #100	Added Toilet Facilities	500		50,500	50	250	50	250	100	500
12-31-20		Status of Ownership				50	25,250	50	25,250	100	50,500
1922	E. & W. #75	Retired detector bars		700	49,800			100	700	100	700
12-31-22		Status of Ownership				50.6	25,250	49.4	24,550	100	49,800
1925	N. & S. #150 E. & W. #125	Additions to Interlocking	5,000	500	54,300	40	1,800	60	2,700	100	4,500
12-31-25		Status of Ownership				49.8	27,050	50.2	27,250		54,300

Note 1—The amounts for above additions and retirements are assumed to be computed on basis of costs reflected by collection bills; i. e., the usual Joint Facility practices in preparing bills.

Note 2—The above statement may be further separated between BUILDINGS and INTERLOCKING PLANT, to record the varying percentages of each, if desired.

Appendix I

(E-3) METHODS USED IN RECAPTURE PROCEEDINGS

Chas. Silliman, Chairman, Sub-Committee; T. F. Darden, C. J. Geyer, W. R. Kettenring, C. A. Knowles, J. T. Powers, H. L. Ripley, W. H. Woodbury.

In the report of this Sub-Committee for 1930, it was stated that a movement had been started in Congress to bring about changes in the Transportation Act with reference to the determination of value and the recapture of so-called excess earnings. The Congress convening in December, 1930 and adjourning in March, 1931, took no action as to such changes. However, on the reconvening of Congress in December, 1931, the matter will come up again, and an understanding of what is being urged is of great interest.

At the beginning of 1930, a Joint Senate Resolution (No. 104) was introduced by Senator Howell and later submitted to the Interstate Commerce Commission for consideration. Under date of January 20, 1930, the Commission wrote pointing out that this resolution would have to be modified in view of the recent Supreme Court Decision in the St. Louis & O'Fallon Railway Case. They then proceeded to discuss broadly the questions involved.

Following this, Senate Bill No. 4005 was introduced by Senator Howell and was submitted to the Interstate Commerce Commission for comment. Under date of May 17, 1930, the Commission submitted their criticisms and suggestions.

During the course of the year 1930, criticisms and comments on S. 4005 were received by the Senate Committee from the National Association of Railway and Utilities Commissioners, the National Industrial Traffic League, the Association of Railway Executives and others, and these papers were also submitted to the Interstate Commerce Commission for consideration.

Under date of January 21, 1931, the Commission wrote the Senate Committee expressing their further views. They pointed out that in its annual report to Congress of December, 1930, the Commission had expressed the opinion that the wise course to pursue was to repeal the recapture provisions of the Transportation Act rather than to attempt to improve them. They favored the determination of a rate base as described in their previous letter, that is, the basic valuation, plus net additions and betterments, plus working capital, less amounts set aside in the depreciation reserve.

In addition, they submitted two appendices, the substances of which they desired Congress to enact into law: Appendix A would prescribe that the Commission shall from time to time determine what percentage of the rate base is necessary to a fair return; Appendix B would modify Paragraph f of Section 19a to the effect that while the Commission shall keep itself informed as to all new construction, retirements, etc., it shall not ascertain new valuations until it has occasion to make use thereof.

The letters contained in addition to the views of the majority the expressions of the opposing Commissioners.

During the present year, proceedings in recapture cases have been along similar lines to those followed last year. The Commission issues a tentative report together with an order to the carrier to pay the sums set forth. Forty days, however, are given for the filing of protest, after which a hearing is set and the questions raised gone into before an Examiner. The first decision since the O'Fallon Case, that of the Richmond, Fredericksburg & Potomac Railroad Company, was released on April 21st. On account of the importance of this decision, the following review of it is given.

RICHMOND, FREDERICKSBURG & POTOMAC RAILROAD COMPANY, FINAL DECISION F.D. 3898

The first hearing in this case began November 16, 1925, and was closed on March 26, 1926. After the O'Fallon decision, the case was reopened on January 20, 1930, and the hearing concluded on February 26, 1930. A report of the Examiners was released on June 26, 1930, and the case was concluded by the hearing of oral argument on October 3 and 4, 1930.

The motion to dismiss because the proceeding had not been instituted within four months of the end of any recapture date was overruled. The Commission stated that the Government was not bound by any statute of limitation in the absence of a Congressional enactment clearly and specifically imposing it and such statutes as were sought by the Carrier to bar the rights of the Government must receive a strict construction in favor of the sovereign.

As to the Terminal Company in Richmond, jointly owned and used with the Atlantic Coast Line, the decision was that this would be separately set up and the Commission refused to permit one-half of the value to be included in the rate base of the Carrier.

The Massaponax Gravel Pit was to be treated as Carrier property and included in the reproduction estimate. This added $94,719.36 to the investment account for the year 1923.

Original Cost

The evidence submitted as to original cost made up in part of actual and in part of estimated costs was approved as representing the best evidence available under the present circumstances of the original cost of the property and was on the whole a fair approximation of such costs.

As to the matter of depreciated original cost, the Commission stated that in order to make any figure, whether original cost or reproduction, representative of the condition of the property at the time of the inquiry, it seemed in principle necessary to make due allowance for the expired units of service life. The Carrier's objection to such depreciation deduction was overruled.

Excess Cost of Ties and Rails

Reviewing the situation as to the excess cost of ties and rails used in replacements, the Commission stated that the method of accounting pursued by the Carrier was that required by the Classification of Accounts which looked upon expense incident to keeping intact the Carrier's property in such articles as ties and rails, even to the extent of replacing them when worn out, as operating expense. They perceived no justification for changing the accounting regulations and no adjustments were made in this matter.

Cost of Reproduction

No changes were made in the estimate of cost of reproduction except what was necessary to include the Massaponax Gravel Pit.

In the matter of index factors, 1920–1923, the recommendation of the Bureau of Valuation to base reproduction estimates on prices during a period of years rather than on those current in the particular year was approved by the Commission. Justification for this was found in the McCardle decision of the Supreme Court.

Cost of Reproduction Less Depreciation

The cost of reproduction was estimated on a period basis and the estimate of depreciation approved relied upon the principle that the value of the various existing parts of the property was less than that of similar new parts in proportion to the loss of total capacity for service or loss of service-life through age or wearing out. There was not any question but that the property was in fact in good repair and well-maintained.

The Carrier's contention as to depreciation was upon the theory that neither obsolescence nor physical deterioration which had not yet interfered with the satisfactory working order of a piece of machinery or other component part of the property was evidence of existing depreciation. This theory, it was stated, was repugnant alike to common experience and to the weight of judicial authority and was rejected in the Commission's Texas Midland decision on authority of the Knoxville Water Company and other cases.

The vice of estimates of depreciation based solely on rules and averages which the courts were seeking to avoid in the cases referred to by the Carrier lay in the fact that any particular property may vary widely from the average. Under the method of the Bureau, actual inspection and the study of proper records were an assurance that departures from an average condition were duly taken into account. The Bureau's estimate was approved.

Land

The difference between the values reported by the Bureau and the claim of the Carrier was due for the most part to the application of different principles. The Bureau's estimates were based on the values of adjacent and adjoining similar land. The Carrier claimed that the lands should have been valued on the basis of what it would have cost to reacquire them. On their interpretation of the Minnesota Rate Case, the Commission approved the Bureau's appraisals. In the matter of the unit prices applied, the Bureau's schedules were approved in almost every case.

Working Capital

There was no dispute in the hearing as to the propriety of the general methods of the Bureau nor as to their result in so far as materials and supplies were concerned. Certain questions regarding the cash were raised, caused principally by the delay in receipts. The Commission ruled that such delays were due to the fact that the rules of the Railway Accounting Officers' Association were not followed and but trifling changes in the previous report were authorized.

Going Concern Value

The Carrier claimed $9,294,391 for Going Concern Value as measured by the cost of development. The Commission, in reviewing the method followed in the cost of development study, ruled that net revenues received by either new or established railroads and the rate of interest thereon were highly *individual* factors depending upon the particular road; and that the experiences of other carriers were of no genuine significance in this connection. Similar claims have been considered by the Commission in other cases and for the reasons given in those cases, such costs were not entitled to consideration in ascertaining the value for rate-making purposes. The statement was made:

> "However, in this case we shall, and do, give, as we deem it, proper consideration to the elements of going concern value in the determination herein of the final single sum values of the property."

Other Elements of Value

On account of the advantage of location and character of the business, the Carrier made substantial claims ($13,500,000) for other elements of value. The Commission argued that value for rate-making purposes could not be fixed on the basis of earnings. It explained that in other valuation decisions they have followed the modern trend of judicial authority upon the subject and stated:

> "The question now before us of giving weight to earning power in the determination of going concern value or other intangible elements of value is in our view, concluded by the holding of the Supreme Court of the United States in the Galveston Case . . . . that earning power must be excluded in determining value for rate-making purposes."

Final Value

The Commission stated that the remaining question at issue was the weight to be accorded original cost and cost of reproduction in determining the value of the structural part of the property. The Carrier contended the dominant weight should have been given to reproduction cost with the complete exclusion of original cost. Contrary views were presented by counsel for the National Association of Railroad and Utilities Commissioners and the National Conference on Valuation of American Railroads. They were unable, however, to state the respective weights that should have been given.

The Carrier urged that its view was supported not only by the Commission's own past decisions but by the predominant judicial authority as well. A great many of the cases cited by the Carrier in support of this view, it was stated by the Commission, were ones where the evidence before the tribunal was largely confined to a statement of reproduction or where the figures with respect to original cost, if presented at all, were

either fragmentary or lacking in accuracy. Under such circumstances, there could be no issue pertaining to the respective weight to be given to each factor.

Beginning with the Smythe vs. Ames Case, a number of decisions were described, for the most part apparently supporting the Commission's position, and the citations ended with a review of the McCardle Case as to which the Commission stated:

> "Justice Butler, however, in delivering the opinion of the court stated that while the reasonable cost of a system of water works is good evidence of its value at the time of construction, it ceased to be of any force or effect after a major change in the price level. In the last analysis, support for respondent's contention in decisions of the Supreme Couit is mainly bottomed upon this statement."

The Commission concluded that both cost of reproduction and original cost must receive consideration in the determination of final value for rate-making purposes. No rule was set as to the weight to be given these elements. To base values in all cases upon an equal consideration of cost of reproduction and original cost or any other fixed proportion would be an artificial rule such as was condemned in the Minnesota Rate Case. The valuation of property must be largely a matter of judgment and not a formula or precise mathematical computation. They stated:

> "We are according such weight to the present cost and original cost of construction as in our judgment is justified by the record. The values found reflect in substantial degree both elements of cost."

Net Railway Operating Income

The Commission stated that the fact that entries in the accounts might have been in conformity with the Classification of Accounts did not preclude them from inquiring into their propriety or the correctness of the results shown thereby.

In the matter of unaudited items, the Commission pointed out their orders required that estimates for unaudited items be made by the Carrier on a reasonable and equitable basis, judged by its experience and best sources of information. It would be utterly impracticable to await the time when all the items affecting a particular year could accurately be audited. They, therefore, ruled that no change was to be made on this account.

As regards the Richmond Terminal Railway Company, the contention of the Carrier that the rentals paid for its use should have been eliminated in making the computation of net railway operating income and an undivided half of the property included in the valuation of its property used, was overruled.

The Massaponax Gravel Pit carried in the balance sheet suspense account was to be included in the reproduction estimates. The revenues and costs of operation were reflected in the net railway operating income and this was approved.

The contention of the Carrier as to certain delayed receipts representing additional compensation for transportation of mail in 1916 and 1917 and paid to it in 1921 and affecting the income of that year was denied and no departure from the Classification of Accounts was made.

Federal Control Settlement

In the matter of profit on materials and supplies, the conclusion of the Commission was that the cost of operation to the Carrier in so far as material and supplies used in maintenance were concerned, was their cost as shown by the final settlement with the Director General. No adjustment of net railway operating income was made on account of this so-called profit.

In the matter of the under-maintenance settlement, the conclusion of the Commission was that the facts of the record were inadequate to permit them to form a judgment as to the extent of under-maintenance, if any, that had occurred and the expenditures required to overcome it in any recapture period. No change was made in the net operating income for under-maintenance.

Income Taxes Paid

In the recapture years the Carrier paid income taxes on amounts which included the trust funds held for the United States under Section 15a. Payment on these funds was erroneous and as the net operating income was reduced thereby, the matter was to be referred to the Treasurer of the United States to decide what amount is refundable on account of such erroneous payment.

Expense Accounting for Depreciation and Retirements

In the matter of expense accounting for depreciation and retirements, the Carrier contended that if depreciation is deducted in determining value, charges consistent with the deductions made must be taken into account as an operating expense in determining income. Thus deductions from income for depreciation were sought based on replacement costs rather than on original cost and are applicable to all items. This claim rests on the decision of the Supreme Court in United Railways vs. West, 280 U.S. 234. The Commission argued that the contentions of the Carrier were based on a misapprehension of the ruling of the court. The case did not arise under Section 19a and it cannot be assumed that the same rules which control in computing the amount of depreciation deductible from gross income in determining questions as to the compensatory character of rates are similarly binding on Congress as the only appropriate basis for determinations of recapturable excess income. If the Carrier is not deprived of a fair return for use of its property, the question as to what are proper deductions to be made from gross income for ascertaining net railway operating income for recapture purposes was stated to be a matter for legislative determination.

The Carrier protested mainly the inconsistency of the methods followed by the Commission in dealing with depreciation in connection with property values, on the one hand, and income, on the other. This, however, it was argued, was inherent in the law, and was not a result of the Commission's application of its terms. The law was none the less valid because of this inconsistency.

Interest

In conformity with the ruling in the O'Fallon Case, interest was not imposed upon the recapturable excess net railway operating income there found prior to the date of the Order. The Carrier was required to hold such excess net railway operating income from the time of receipt as trustee for the United States and an accounting for all earnings received on such funds while so held by it as trustee was to be required of the Carrier.

With individual opinions by Commissioners Eastman and Mahaffie dissenting in part and by Commissioner Lewis concurring, there followed an Order directing that within ninety days from April 7, 1931, the Carrier should transmit to the Secretary of the Commission at Washington, D. C., the sum of $696,706. It was further ordered that a statement be rendered of any and all interest and profit received on such sums held in trust for the United States and that any such interest and profits should be paid to the Commission within 120 days from the date of the Order.

Following this decision and order to make a payment, the Carrier did nothing. On the expiration of the time limit, the Comptroller General of the United States advised the Carrier to the effect that the amounts due them by the Government monthly for mail and other services would be withheld until the recapturable amounts had been deposited. The next move of the Carrier in this situation has not been announced.

NORFOLK & WESTERN RAILWAY COMPANY, F.D. 3865

Under date of February 13, 1931, the recapture report of the Norfolk & Western Railway Company, F.D. No. 3865, was issued by the Commission. The recapturable amount for the period 1920–1926 was announced to be about $18,000,000. The Carrier filed formal protest and a hearing was set for June 1, 1931. At this hearing, application was made for conference, dealing with such subjects as: Additions and Betterments, Land, Investment in Road & Equipment, Working Capital, Original Cost and Net Railway Operating Income. The hearing was adjourned pending this conference and was to be resumed on November 3rd.

ORDER NO. 15100

Under date of July 28, 1931, the Commission issued its decision and Order in Docket No. 15100, Depreciation Charges of Steam Railroad Companies. Briefly, this provides for the setting up of a depreciation reserve for each depreciable R.&E. account, the same to become effective January 1, 1933. One of the arguments presented by the Commission in favor of this order was the protection it would afford the carriers in recapture proceedings.

Appendix J

(F-2) METHODS AND FORMS FOR HANDLING THE I.C.C. REQUIREMENTS UNDER ORDER NO. 15100—DEPRECIATION CHARGES OF STEAM RAILWAY COMPANIES

W. R. Kettenring, Chairman, Sub-Committee; B. A. Bertenshaw, E. S. Butler, T. F. Darden, C. J. Geyer, C. R. Harte, W. W. James, Henry Lehn, W. T. Mead, A. T. Powell, J. T. Powers, F. C. Sharood, G. R. Walsh, Louis Wolf.

The final report on depreciation charges of steam railway companies was served on the railway companies in the early part of September, 1931.

Under this order the railroads are required to inaugurate a system of depreciation accounting on all railroad property listed in the order as depreciable. This includes equipment, but excepts Engineering, Land for transportation purposes, Track laying and surfacing, Roadway small tools, Assessments for public improvements, Revenues and operating expenses during construction, Cost of road purchased, Reconstruction of road purchased, Other expenditures—Road, and Unapplied construction material and supplies. It also excepts Grading and Ballast which are reserved for further study, and the apportionment of Account 1 and Accounts 71 to 77, inclusive, will be given further consideration in the revision of the accounting classification.

Roads are required to file with the Commission not later than September 1, 1932, estimates of the percentage rates applicable to the ledger values of the respective primary accounts for the classes of property indicated as depreciable. They are also required to inaugurate depreciation accounting effective January 1, 1933, using rates which the Commission will prescribe by temporary orders, based on the receipt from the railway companies of the above mentioned estimate of percentage rates applicable to their respective properties.

History

The early history of this order was set forth in the report of this Committee published in Vol. 31 of the Proceedings, pages 612 to 618, and was carried forward to October, 1930, in the Committee's reports published in Vol. 31, pages 877 and 878, and Vol. 32, page 519. The issuance of the present report is the first public development since those recorded in the Committee's reports above mentioned.

Bibliography

An extended bibliography of articles on depreciation was published in the reports of this Committee for the years 1929, 1930, and 1931—Proceedings, Vol. 30, pages 619 and 620; Vol. 31, pages 938 and 939, and Vol. 32, page 536, and will be brought up to date in the report of the Committee for the current year.

The present order corresponds in many particulars with the order issued in 1926, which was quite fully discussed in the report published in Vol. 30 of the 1929 Proceedings.

Insofar as the present order is similar to the previous order, no extended discussion will be included in this report, but reference will be made to the part of the Committee's report of 1930 wherein the corresponding order is discussed.

1st Ordering Paragraph:

It is ordered, That the order herein, entered November 2, 1926, be, and it is hereby, vacated and set aside.

This merely vacates the order of November 2, 1926, which is superseded by the current order.

2nd Ordering Paragraph:

That all steam railroad companies subject to the interstate commerce act shall, effective January 1, 1933, institute depreciation accounting, as hereinafter prescribed, with respect to the following classes of common-carrier property, found in the accompanying report to be classes of property for which depreciation charges may properly be included under operating expenses:

Road:
- Underground power tubes.
- Tunnels and subways.
- Bridges, trestles, and culverts.
- Elevated structures.
- Ties.
- Rails.
- Other track material.
- Right-of-way fences.
- Snow and sand fences and snowsheds.
- Crossings and signs.
- Station and office buildings.
- Roadway buildings.
- Water stations.
- Fuel stations.
- Shops and engine houses.
- Grain elevators.
- Storage warehouses.
- Wharves and docks.
- Coal and ore wharves.
- Gas-producing plants.
- Telegraph and telephone lines.
- Signals and interlockers.
- Power dams, canals, and pipe lines.
- Power plant buildings.
- Power substation buildings.
- Power transmission systems.
- Power distribution systems.
- Power line poles and fixtures.
- Underground conduits.
- Miscellaneous structures.
- Paving.
- Roadway machines.
- Shop machinery.
- Power plant machinery.
- Power substation apparatus.

Equipment:
- Steam locomotives.
- Other locomotives.
- Freight-train cars.
- Passenger-train cars.
- Motor equipment of cars.
- Floating equipment.
- Work equipment.
- Miscellaneous equipment.

Provided, That in case a steam railroad company can show that the service life of its property is dependent upon a particular source of traffic, upon exhaustion of which the operation of the property for common-carrier purposes must in all probability be abandoned, and that the time of such exhaustion can be predicted with a reasonable degree of accuracy, then the entire property of such railroad may be classed as depreciable, in which case, however, depreciation of this character shall be provided for through a special amortization account, instructions as to which will hereafter be given.

This is identical with the 1st paragraph of the earlier order with the exception of the omission of ballast which is reserved for further study.

3rd Ordering Paragraph:

That in the application of this order the terms "service life," "service value," "salvage value," "straight-line method," and "ledger value" shall be construed in accordance with the definitions and explanations given therefor in the accompanying report.

Reference is here made to the term "salvage value" whereas the term "net salvage value" is used in the earlier order. The present order defines service value as the differ-

ence between ledger value and salvage value, thus permitting the cost of removing the property and recovering the salvage to be charged direct to operating expenses in lieu of being charged to the depreciation reserve as was previously required. The reference to extraordinary repairs contained in the previous order is omitted from this order.

4TH ORDERING PARAGRAPH:

> That depreciation accounting, as referred to in this order, shall mean—
> (a) The charging to operating expenses and the crediting to a depreciation reserve during the service life of the property, as hereinafter provided, of amounts which will approximate the loss in service value not restored by current maintenance and incurred in connection with the consumption or prospective retirement of property in the course of service from causes against which the carrier is not protected by insurance, which are known to be in current operation, and whose effect can be forecast with a reasonable approach to accuracy; and—
> (b) The crediting of the ledger value of property at time of retirement to the appropriate primary road and equipment accounts and the charging of the service value of such property when retired to the depreciation reserve.

The requirements of the order are very much simplified by the elimination of the provision of extraordinary repairs incorporated in the corresponding paragraph of the earlier order. This requirement was quite generally considered as impracticable and unworkable. The purpose which the provision for extraordinary repairs was intended to serve will in part be served by improving the definition of unit of property which will no doubt provide considerably smaller units will be handled as retired and replaced than has been the practice under the current accounting classification. The proposed plan is more practical than the original one and better meets the valuation requirements, as the accounts will reflect more nearly the cost of property in service. It is intended to include the revised definition of unit of property in the forthcoming accounting classification.

The provision in the original order for the maintenance of credit accounts under operating expenses through which to clear retirement charges is omitted from this order, and credits to the Investment Account for retired property are to be offset directly to the depreciation reserve.

5TH ORDERING PARAGRAPH:

> That the annual charges to operating expenses for currently accruing depreciation shall be computed, as hereinafter provided, at such percentage rate of the ledger value of the property in question that the service value may be distributed under the straight-line method in equal annual charges to operating expenses during the estimated service life of the property.

Similar to the 4th paragraph of the earlier order.

6TH ORDERING PARAGRAPH:

> That all depreciation charges to operating expenses and concurrent credits to the depreciation reserve shall be made monthly in conformity with the group plan of accounting for depreciation, as explained in the accompanying report and as hereinafter provided, and in determining such monthly charges and credits the annual percentage rates shall be applied to the total ledger value (see paragraph 11), as of the first of each month, of the respective primary accounts covering the classes of property hereinbefore specified, and the result divided by 12; but that for corporate ledger and balance-sheet purposes the depreciation reserve shall be regarded and treated as a single composite reserve.
> Provided, That for purposes of analysis each carrier shall maintain subsidiary records in which the reserve is broken down into component parts corresponding to such primary accounts as include property hereinbefore found to be depreciable, showing in these records also in complete detail by such primary accounts the current credits and debits to the reserve; and that such detailed information shall be reported annually to this Commission and to the Commissions of all States in which the carrier operates.

Similar in intent to the 5th paragraph of the earlier order, but providing that subsidiary records shall be maintained by the carrier in which the depreciation reserve shall be recorded together with the detail of subsequent debits and credits, and providing further that this detailed information shall be reported annually to the Commission and to the States in which the carrier operates.

7TH ORDERING PARAGRAPH:

That in determining the monthly depreciation charges to operating expenses and the corresponding credits to the depreciation reserve a composite annual percentage rate shall be used for each of the primary accounts in the classification of road and equipment covering the classes of property hereinbefore specified; and that the composite rates so used shall be those which are from time to time prescribed by the commission.

Similar to the requirements of a portion of the 6th and 7th paragraphs of the earlier order.

8TH ORDERING PARAGRAPH:

That for the assistance of the Commission in prescribing the composite annual percentage rates to be effective beginning January 1, 1933, each operating steam railroad company subject to the act shall, not later than September 1, 1932, file with the Commission estimates of said percentage rates applicable to ledger values of the respective primary accounts covering the classes of property hereinbefore specified, owned and/or used by such company; that such composite percentage rates shall be based upon estimated service values and service lives developed by a study of the company's history and experience and such engineering and other information as may be available with respect to future prospects, and shall produce a charge to operating expenses for the primary account, where more than one class of property is covered by the account, equal to the sum of the amounts that would otherwise be chargeable for each of the various classes; and that such estimates shall be accompanied by a sworn statement showing the bases therefor and the methods employed in their computation.

Similar to the requirements of a portion of the 6th and 7th paragraphs of the earlier order.

9TH ORDERING PARAGRAPH:

That upon the retirement of a unit of depreciable property, whether or not the cause of the retirement is a recognized factor in depreciation, as explained in the accompanying report, the service value shall be charged in its entirety to the depreciation reserve.

Provided, That if the cause of retirement is not a recognized factor in depreciation, but is a cause against which the carrier is insured, the depreciation reserve shall be credited with the full amount of insurance recovered; and

Provided, further, That if the cause of the retirement is not a recognized factor in depreciation and the loss is not covered by insurance, the carrier may, upon proof that the charge to the depreciation reserve will result in undue depletion thereof, and with the approval of the Commission, charge the service value to an appropriate suspense account and distribute it from that account over such period of years and to such accounts as the Commission may approve.

This is similar in intent to the 9th paragraph of the earlier order, except that the accounting for retirements is handled directly between the Investment Account and the depreciation reserve in lieu of being carried through an operating credit account as provided for in the original order.

10TH ORDERING PARAGRAPH:

That in determining the amounts to be respectively credited to the primary road and equipment accounts and charged to the material and supplies account and to the depreciation reserve in the case of the retirement of property, amounts for specific units shall be used so far as practicable; but that where this is impracticable

because of the relatively large number and small size of the units, average amounts shall be used.

Similar to the 10th paragraph of the earlier order.

11TH ORDERING PARAGRAPH:

That as of January 1, 1933, each operating steam railroad company shall establish and thereafter shall maintain subsidiary records covering the cost of all carrier property owned and/or used for which depreciation accounting is herein prescribed; that the manner in which such subsidiary records shall be kept and the method of determining the amounts to be included therein as of January 1, 1933, and for subsequent property changes, shall be in accordance with finding 8 of the accompanying report; and that the ledger value of carrier property used for depreciation purposes thereafter shall be the costs entering into the subsidiary records so provided subject to the provisions of finding 9.

The method for determining the depreciation base provided for in the present order is less complicated than that provided for in the earlier order. In effect it requires that the base be composed of the reproduction cost new determined by the Bureau of Valuation for all property which was included in the Engineering Reports of the Commission, and remaining in service as of the effective date of the order, to which shall be added the improvements installed and reported under the provisions of Valuation Order No. 3. The provision of the earlier order that property installed between July 1, 1914 (effective date of present classification) and the date of valuation should be restated to its original cost, and that the total of the reproduction cost of the property installed prior to July 1, 1914, and remaining in service, plus the ledger value of property installed subsequent to that date, should be scaled down to the equivalent of the Investment Account of the carrier, is omitted from the present order.

12TH ORDERING PARAGRAPH:

That with respect to common-carrier property used but not owned operating steam railroad companies shall include in operating expenses charges for depreciation upon the same basis as for owned property and shall maintain the same records of service lives, salvage values, etc., as are required for owned property.

Provided, That this shall not apply to units of property the rent of which is included in net railway operating income, or units accounted for by the user as a joint facility under the joint-facility rules of the Commission's classifications nor, with the approval of the Commission, to other units of property with respect to which it is shown that there are special circumstances and conditions justifying such exception.

The present order is more definite in prescribing the records which shall be maintained and the accounting which shall be performed for carrier property "owned but not used" and "used but not owned," although the 15th paragraph of the earlier order no doubt would have been construed to require similar accounting.

13TH ORDERING PARAGRAPH:

That prior to the effective date of the order each operating steam railroad company shall make an estimate, in accordance with the principles set forth for the determination of currently accruing depreciation, of the amount of accrued depreciation in the depreciable property as of January 1, 1933, such estimate to be broken down into component parts corresponding to the primary investment accounts for which depreciation accounting is herein prescribed, and shall enter the same in a record to be kept for future reference.

Provided, That the amount so ascertained shall be subject to check and revision by the Commission and shall be treated as a tentative estimate until such time as it has been approved by the Commission.

This paragraph requires an estimate of past accrued depreciation similar to that required in the 12th paragraph of the previous order. The requirement of the earlier

order that this accrued depreciation shall be credited to the reserve and concurrently debited to Profit and Loss, is omitted from the current order, but the carrier is required to maintain a record of the accrued depreciation as of the date of the order, and is given the option of crediting this amount in whole or in part to the depreciation reserve and concurrently charging the same to Profit and Loss.

14TH ORDERING PARAGRAPH:

> That each operating steam railroad company shall keep a record of property retirements which shall reflect the service life and percentage of salvage value of each important class of property hereinbefore specified; shall maintain in convenient and accessible form engineering and other data bearing on prospective service lives; and shall be prepared at any time upon direction by the Commission to compute and submit, for the Commission's approval, new percentage rates to take the place of those based upon service lives or percentages of salvage value found to be inaccurate.

Similar to the 13th paragraph of the earlier order.

15TH ORDERING PARAGRAPH:

> That all accounting procedure specifically provided in this order shall be subject to such modification as may be necessary to bring it into harmony with such accounting classifications as may be prescribed by the Commission for concurrent or subsequent application.

Similar to the 16th paragraph of the earlier order.

The future work of the Sub-Committee will be determined largely by the new classification of accounts and by the directions which may be issued hereafter by the Board of Direction of the Association.

Appendix K

(F-3) METHODS FOR AVOIDING DUPLICATION OF EFFORT AND FOR SIMPLIFYING AND CO-ORDINATING WORK UNDER THE REQUIREMENTS OF THE INTERSTATE COMMERCE COMMISSION, WITH RESPECT TO ACCOUNTING, VALUATION AND DEPRECIATION

F. C. Sharood, Chairman, Sub-Committee; E. Y. Allen, T. F. Darden, C. C. Haire, V. H. Doyle, W. R. Kettenring, A. Holmead, C. A. Knowles, H. L. Restall, H. L. Ripley, J. H. Hande, Chas. Silliman, J. Stephenson.

The Committee last year made a progress report covering this subject, and called attention to the requirements of various bureaus of the Interstate Commerce Commission. For convenience, these bureaus that have jurisdiction over the carriers with respect to accounting, valuation and depreciation are repeated again, viz:

1 —Bureau of Accounts
1a—Bureau of Accounts—Depreciation Section
2 —Bureau of Valuation
3 —Bureau of Finance
4 —Bureau of Statistics

Each of these organizations is headed by a director and their efforts are co-ordinated by the Commission as a whole. It is the practice for the Commission to subdivide itself into Divisions, each of which has direction of certain bureaus or certain other activities of the Commission. To show this organization, a chart has been prepared, which indicates the organization of the Commission. (See Exhibit A.)

Exhibit A chart shows somewhat the isolation of each bureau and their independence. This isolation may be more profound than is apparent because of the

admitted overworked situation of the Commissioners and their obvious inability to come in contact with detail.

The organization of the Commission and its bureaus is also shown to indicate that unlike railroad organizations and other corporations who have one head and departments handling special features, that it may be difficult to co-ordinate all activities so as to avoid duplication of effort.

Duplication of effort in railway organizations is generally considered to be the same work being done either in whole or in part by two or more departments. Simplification on the other hand is doing work in a less elaborate manner with regard to detail. It is considered by the Committee that its efforts should be directed in calling attention to certain duplications in the Commission's requirements that appear obvious in carrying out the mandatory requirements as concerns reports, records, etc., but it is not amiss to call attention that railway companies may permit duplications and elaborate practices to grow under the cloak of departmental prerogatives or misconception that it is the traditional right of certain departments to be responsible for handling a part of some requirement and another department to handle another part with the consequence in some instances that costly methods are used with much time consumed. This condition exists largely where there may be a misconception as to what is engineering, accounting, valuation or clerical work. The usual result in carrier organizations is to create various specialist groups to treat different phases of a mandatory requirement and for someone to attempt to co-ordinate the efforts of all.

The picture as relates to the Commission is a little different. Each bureau has its own complete organization and as compared with carrier organizations seems to be more independent, i. e., the Bureau of Accounts endeavors to avoid encroaching in the field of the Bureau of Valuation and vice versa as regards other bureaus, the situation is much the same.

The effect of the various bureaus' policies on railway work is quite marked. The Bureau of Accounts deals entirely with accounting and professes no interest in valuation, whereas the Bureau of Valuation must, of necessity, deal with the accounting and in order to carry on their work, requires reports and records under Valuation Order No. 3 that are for the most part the substance of the accounts. This is true of the Bureau of Statistics who have jurisdiction over a system of reports that shows the substance over which both the Bureau of Accounts and Valuation have administrative functions.

The Bureau of Finance likewise has certain administrative functions over the substance of the accounting results and the records required to be maintained by the carriers for the Bureau of Valuation.

While carrier organizations can deal independently with these various bureaus as regards their special functions, yet this distinct allocation of functions has had its effect on the carriers' methods. For the most part, it has led to accounting departments handling all their affairs with the Bureau of Accounts; for valuation and engineering departments to deal with the Bureau of Valuation. The general rule is for Accounting Departments to be the organization delegated to deal with the Bureau of Statistics and Finance.

With the institution of depreciation accounting, another organization of the Commission (Depreciation Section) will assume an administrative function. Many of the records that carriers must maintain will overlap or duplicate (in part) records that come under the jurisdiction of the Bureau of Valuation in which the Bureau of Finance also have certain interest.

The Committee therefore calls attention that it must be borne in mind that the Bureau of Accounts, Valuation, Statistics, Finance and the Depreciation Section are

carrying out mandates laid down by law to the Commission under various provisions of the Interstate Commerce Act, and the Transportation Act of 1920, in accordance with the interpretations of the Commission in their duty of regulating carriers.

It must also be observed that various carriers have organized their work in complying with the Commission's Orders, regulations, etc., not along uniform lines, and in addition vary materially as to degree of simplicity and duplication in carrying out the requirements imposed upon them.

The Committee, after studying various forms of organization used by carriers and that of the Commission, and in reviewing the many records and reports that are required, have come to a number of conclusions as follows:

(1) The manner in which the Commission is organized causes some duplication of effort by carriers in accounting, valuation and statistical work, which may now become more extensive with the new depreciation requirements.

(2) The Committee is of the conclusion that the Commission is partly alive to this situation, and its recent report regarding depreciation accounting said

> "It is a matter of vital importance to harmonize the requirements for valuation and depreciation accounting purposes, so that unnecessary duplication of effort will be avoided."

(3) That carriers may themselves cause duplication and lack of simplification by their own methods of organizing to comply with the requirements.

- (a) The lack of standardization as to forms, methods and organization, may be largely responsible for duplication and lack of simplification by some carriers.
- (b) No one carrier organization is vested with the duty and responsibility to act as a clearing house and co-ordinate all accounting, valuation and related effort as one matter.
- (c) That no single carrier organization is authorized to co-ordinate and contact with the Interstate Commerce Commission with a view of constructively simplifying the practices as coming within the scope of accounting, valuation, depreciation, etc.
- (d) It has become apparent that constructive recommendations to aid the Commission can only be made by a composite carrier organization, consisting of personnel that will deal as a single matter with all accounting, valuation and engineering features. Individual carrier organizations, specializing in any one of these fields, frequently make suggestions and recommendations out of harmony with the aims of the other.

The Committee feels that there is little to be gained by continuing the subject in view of the impracticability of accomplishing or making any specific recommendations unless the united support of other carrier organizations is obtained.

REPORT OF COMMITTEE VIII—MASONRY

Meyer Hirschthal, *Chairman;*
J. T. Andrews,
F. E. Bates,
H. I. Benjamin,
M. C. Blanchard,
G. E. Boyd,
Kennerly Bryan, Jr.,
M. F. Clements,
T. L. Condron,
Hardy Cross,
W. F. Cummings,
Theo. Doll,
G. F. Eberly,
L. V. Haegert,
J. L. Harrington,
A. D. Harvey,
W. K. Hatt,
A. C. Irwin,
G. M. Johnson,
A. R. Ketterson,
J. A. Lahmer,
J. F. Leonard, *Vice-Chairman;*
A. N. Laird,
O. V. Parsons,
C. P. Richardson,
L. E. Ritter,
D. A. Ruhl,
D. B. Rush,
F. E. Schall,
C. P. Schantz,
L. W. Skov,
G. R. Smiley,
A. W. Smith,
G. L. Staley,
I. F. Stern,
L. W. Walter,
C. C. Westfall,
C. A. Whipple,
G. C. Williams,
P. H. Winchester,
J. J. Yates,

Committee.

To the American Railway Engineering Association:

Your Committee respectfully presents herewith report covering the following subjects:

(1) Revision of the Manual (Appendix A).
(2) Principles of Design of Plain and Reinforced Concrete (Appendix B).
(3) Science and Art of Concrete Manufacture (Appendix C).
(5) Specification for Foundations (Appendix D).
(6) Methods and Practices of Lining and Relining Tunnels (Appendix E).
(8) Study of Art of Repairing Deteriorating Concrete (Appendix F).

The Committee reports progress on (4) Contact with Joint Committee, (7) Clearances, (9) Expansion Joints.

The following resolution was unanimously adopted by the Committee:

"Resolved, that the Chairman of the Buildings Committee and the Board of Direction be informed of the objection of the Masonry Committee to the printing in the Manual of the proposed Specifications for Concrete Used in Railway Buildings, on the ground that while the material covered by the proposed specifications is similar to that of the Masonry Committee now in the Manual, there have been important omissions as well as immaterial changes which would result if the proposed specifications were adopted, in the presence in the A.R.E.A. Manual, of two specifications for the same material of construction not identical in form for the corresponding provisions though identical in intent with serious omissions of important matter now included in the Specifications for Concrete."

Action Recommended

1. That the changes in the Manual in Appendix A be approved for printing as revised material for the Manual.

2. That Appendices B, C, D, E, and F be received as information.

Respectfully submitted,

The Committee on Masonry,

M. Hirschthal, *Chairman.*

Bulletin 344, February, 1932.

Appendix A

(1) REVISION OF MANUAL

J. F. Leonard, Chairman, Sub-Committee; Hardy Cross, T. L. Condron, G. F. Eberly, A. R. Ketterson, J. A. Lahmer, A. N. Laird, D. B. Rush, L. W. Skov, L. W. Walter, J. J. Yates.

Your Committee recommends the adoption of the following revisions and additions of the present recommended practices now appearing in the Manual:

PROPOSED REVISIONS OF SPECIFICATIONS FOR PORTLAND CEMENT CONCRETE, PLAIN AND REINFORCED

Present Article 7

Coarse aggregate shall grade in size from fine to coarse, preferably within the following percentages, by weight:

Passing maximum size sieve	Not less than 95 per cent
Passing sieve ½ the maximum	Not more than 75 per cent
Passing No. 4 sieve	Not less than 40 per cent Not more than 6 per cent

The maximum size of coarse aggregate shall be not more than three inches and shall be not more than four-fifths of the minimum clear space between reinforcement bars or mesh.

Proposed Article 7

Coarse aggregate shall grade in size from fine to coarse, preferably within the following percentages, by weight:

Passing maximum size sieve	Not less than 95 per cent
Passing sieve ½ the maximum	Not more than 75 per cent
Passing No. 4 sieve	Not less than 40 per cent Not more than 6 per cent

The maximum size of coarse aggregate shall be not more than three inches nor more than one-half the minimum clear space between reinforcement bars or mesh opening, or between reinforcement and side forms; nor more than one-fourth the least dimension of the member.

Proposed Addition to Article 10

Add paragraph:

"Reinforcing materials shall be stored in racks in such manner as to avoid contact with the ground".

Proposed Addition to Articles 15 and 17

Note.—The Canadian sack of cement weighs 87½ lb., and the Imperial gallon is 1.2 U.S. gallons, and in determining the gallons of water per sack of cement this should be recognized.

This note should be identified by an asterisk placed after "General"—Article 15, and in Article 17, opposite the heading "Amount of Water".

Place U.S. in front of "Gallons of Water per sack of Cement".

Present Table Article 17

Amount of Water *Class of Concrete* *Compression Strength* *Lb. per sq. in. 28 days*	*Gallons of Water* *Per Sack of Cement*
3500	5.00
3000	5.50
2500	6.25
2000	7.00
1500	8.00

Proposed Table Article 17

Amount of Water *Class of Concrete* *Compression Strength* *Lb. per sq. in. 28 days*	*U.S. Gallons of Water* *Per Sack of Cement*
3500	5.00
3000	5.50
2500	6.25
2000	7.00

Present Article 22

Specimens for compression tests shall be made and stored in accordance with the "Standard Method of Making and Storing Specifications of Concrete in the Field" (Serial Designation C 31–21) of the American Society for Testing Materials. These specimens shall be tested in accordance with "Tentative Method of Making Compression Tests of Concrete" (Serial Designation C 39–21 T) of the American Society for Testing Materials.

Proposed Article 22

Specimen for compression tests shall be made and stored in accordance with the "Standard Method of Making and Storing Specimens of Concrete in the Field" (Serial Designation C 31–31) of the American Society for Testing Materials. These specimens shall be tested in accordance with "Standard Method of Making Compression Tests of Concrete" (Serial Designation C 39–27) of the American Society for Testing Materials.

Proposed Addition to Article 31

Add paragraph

"High frequency vibration may be used in compacting the concrete. The consistency of the mixture and the period of vibration shall be such that the resulting concrete will be free from segregation, honeycomb, or accumulations of water or laitance at the surface."

Proposed Change to Article 85

Change definition of formula (7) from "Position of Resultant Compression" to "Position of Resultant of Compressive Stresses".

Proposed Addition to Article 86

Add notation "h = Unsupported length of columns".

Proposed Change to Article 106

Wherever capital "S" occurs as a notation change to lower case "s".

Appendix B

(2) PRINCIPLES OF DESIGN OF REINFORCED CONCRETE ARCHES

A. N. Laird, Chairman, Sub-Committee; J. F. Leonard, T. L. Condron, Hardy Cross, A. C. Irwin, A. R. Ketterson, L. W. Skov, A. W. Smith, C. C. Westfall, Theo. Doll, J. L. Harrington, L. E. Ritter, C. P. Schantz, C. C. Williams, I. F. Stern.

Your Committee reports progress on the subject of Concrete Arches and presents the following report as information and for suggestions in continuation of that submitted by the Committee last year. It is the intention to follow this report during the ensuing year with a section covering the details of design and construction, following which the entire subject-matter will be submitted in the form of recommended specifications for the Design and Construction of Reinforced Concrete Arches for Railroad Loading.

II—DESIGN (Continued)

4. Selection of Form

The selection of the form of arch axis shall be based on a preliminary analysis of the dead load line of pressure, after assuming the rise and span of the arch ring. The preliminary form selected may require modification after analysis in order to more closely approximate the line of pressure under combined conditions of loading, or to meet the requirements of appearance.

5. Preliminary Selection of Crown Thickness

The crown thickness of the arch ring shall be assumed, based on the span length and the loadings.[1]

$$d = \sqrt{l} + .1l + .005\,W + .0025\,W_1.$$

where d = crown thickness in inches.
l = clear span in feet.
W = live load in pounds per square foot, uniformly distributed.
W_1 = dead load at the crown in pounds per square foot uniformly distributed.

6. Notations and Symbols

The following notations and symbols will be employed:

Δs = length of a division of the arch ring measured along the arch axis.
n = number of divisions in one-half the arch for symmetrical arches. or total number of divisions in the arch for unsymmetrical arches.
l = span of arch axis, in feet.
f_a = average unit compression in concrete of arch ring due to thrust.
t_e = coefficient of linear temperature expansion.
t° = number of degrees rise or fall in temperature.
E_c = modulus of elasticity of concrete.

At the crown,

H_c = horizontal thrust.
V_c = vertical shear.
R_c = resultant of H_c and V_c.
M_c = bending moment.

[1] An empirical formula is generally used to assist the designer in his selection. The following formula by F. F. Weld is suggested:

At any point on the arch axis, with coordinates x and y referred to the crown as origin,

N = thrust (normal) on radial section.
V = shear on radial section.
R = resultant force on radial section, resultant of N and V.
e = eccentricity of thrust on section, or distance of N from the arch axis.
d = depth of section.
I = moment of inertia of section including that of steel $I_c + nI_s$.
A = area of section including steel $A_c + nA_s$.
p = steel ratio for total steel at section.
d' = embedment of steel from either upper or lower surface.
M = moment = NE.
x = horizontal coordinate of any point on the arch axis referred to the arch axis at the crown as origin.
y = vertical coordinate of any point on the arch axis referred to the arch axis at the crown as origin.
m_L = moment at any point on left half of arch axis of all external loads (P1, P2, etc.) between the point and the crown.
m_R = moment at any point on right half of arch axis of all external loads between the point and the crown.

7. Basis of Design and Formulae

The analysis of hingeless arches shall be based on the Elastic Theory. The loads from the spandrel construction or fill over the arch ring shall be assumed applied vertically. The live load shall be the Railroad Engine Loading and shall be treated as a moving load with an impact allowance in accordance with provision in Section 2 (c). The conditions of live loading which produce maximum moments, shears and thrusts may be determined by influence lines or by assuming the following positions of live loading.

(1) For maximum positive moment at the crown, assume the middle ¼ of the span loaded.
(2) For maximum negative moment at the crown, assume all of the span except the middle ¼ loaded.
(3) For the maximum positive moment at the springing line, assume ⅝ of the span loaded from opposite end.
(4) For maximum negative moment at the springing line, assume the adjacent ⅜ of the span loaded.

The temperature variation for which the structure is to be designed shall be based on the records of temperature variation for the locality of the structure.[1]

The following formulae are derived from the deflection of curved beams in which the radius of curvature is large compared with the depth, and presuppose fixity at the ends of the arch ring and unyielding supports. These formulae are applicable to symmetrical arches, which for analysis must be divided into sections, such that for each section $\frac{\Delta S}{I}$ is a constant.

[1] Available information indicates that for thin sections of concrete the temperature of the concrete closely approximates the variation in air temperature except for sudden changes or extreme variations of short duration. In the case of heavy concrete sections the variation in the concrete temperature as compared with the air temperature is substantially decreased. It is recommended that, depending upon the thickness of the concrete section, not more than 75 per cent nor less than 50 per cent of the mean air temperature variation, above and below the mean air temperature of the construction period, be used as the basis for design.

FORMULAE FOR THRUST, SHEAR AND MOMENT

(A) Dead Load and Live Load[1]

$$H_c = \frac{n\Sigma(m_L + m_R)y - \Sigma(m_L + m_R)\ \Sigma y}{2[n\Sigma y^2 - (\Sigma y)^2]}$$

$$V_c = \frac{\Sigma(m_L - m_R)x}{2\Sigma x^2}.$$

$$M_c = \frac{\Sigma(m_L + m_R) - 2H_c\Sigma y}{2n}$$

$$M = M_c + H_c y + V_c x - m_L$$

$$M = M_c + H_c y - V_c x - m_R$$

[1]Values of m_R, m_L, x_R, x_L, y_R, and y_L should be substituted as positive. All summations refer to one-oalf of the arch axis.

(B) Temperature[2]

$$H_c = \frac{E_c I}{\Delta s}\cdot\frac{t_e t^\circ l n}{2[n\Sigma y^2 - (\Sigma y)^2]}$$

$$M_c = -\frac{H_c\Sigma y}{n}$$

$$M = M_c + H_c y$$

[2] Value of t° should be inserted positive for a rise of temperature and negative for a drop of temperature. The value of E_c must be assumed sufficiently large for the strength of concrete specified.

(C) Rib Shortening[3]

The thrusts and moments due to rib shortening produced by an average compressive stress f_a may be found by substituting for t in the above formulae for temperature the value $t^\circ = \frac{f_a}{E_c t_e}$ resulting in the following:

$$H_c = -\frac{I}{\Delta s}\cdot\frac{f_a l n}{2[n\Sigma y^2 - (\Sigma y)^2]}$$

$$M_c = -\frac{H_c\Sigma y}{n}$$

$$M = M_c + H_c y$$

[3] Values of moments and thrusts for rib shortening are of the same sign as for a drop of temperature.

In the design of unsymmetrical arches, the following formula may be solved simultaneously after the substitution of numerical values of coefficients. The entire arch ring must be divided into sections such that for each section $\frac{\Delta s}{I}$ is a constant.[4]

FORMULAE FOR THRUST, SHEAR AND MOMENT

(D) Dead Load and Live Load[5]

$$H_c\Sigma y^2 + V_c(\Sigma x_L y_L - \Sigma x_R y_R) + M_c\Sigma y - \Sigma my = 0$$

$$H_c(\Sigma x_L y_L - \Sigma x_R y_R) + V\Sigma x^2 + M_c(\Sigma x_L - \Sigma x_R) - \Sigma m_L x_L + \Sigma m_R x_R = 0$$

$$H_c\Sigma y + V_c(\Sigma x_L - \Sigma x_R) + nM_c - \Sigma m = 0$$

$$M_L = M_c + H_c y_L + V_c x_L - M_L$$

$$M_R = M_c + H_c y_R - V_c x_R - m_R$$

[4] A point near the crown or highest point of the arch ring should be selected as the origin of coordinate and the x and y axis should be selected tangent and perpendicular respectively to the arch axis at this point.

(E) Temperature

$$H_c\Sigma y^2 + V_c(\Sigma x_L y_L - \Sigma x_R y_R) + M_c\Sigma y - \frac{I}{\Delta s} \cdot t_e t^\circ l E_c = 0$$

$$H_c(\Sigma x_L y_L - \Sigma x_R y_R) + V_c\Sigma x^2 + M_c(\Sigma x_L - \Sigma x_R) = 0$$

$$H_c\Sigma y + V_c(\Sigma x_L - \Sigma x_R) + nM_c = 0$$

$$M_L = M_c + H_c y_L + V_c x_L$$

$$M_R = M_c + H_c y_R - V_c x_R$$

(F) Rib Shortening

Use formulae for thrusts, shear and moment as given above under paragraph (E), Temperature, with value of t° as determined by formula

$$t^\circ = \frac{f_a}{E_c t_e}$$

(G) Determination of Stresses

After the values of H_c, V_c and M_c have been obtained the resulting stresses may be determined graphically by constructing the equilibrium polygons and corresponding pressure lines or by computation. In case the maximum stresses resulting from the various combinations are not within the allowable limits the arch thickness, shape, or both shall be revised and the arch again analyzed.

Appendix C

(3) PROGRESS IN THE SCIENCE AND ART OF CONCRETE MANUFACTURE

L. W. Walter, Chairman, Sub-Committee; H. I. Benjamin, Kennerly Bryan, Jr., H. G. Blanchard, L. V. Haegert, A. D. Harvey, W. K. Hatt, A. C. Irwin, G. M. Johnson, J. A. Lahmer, O. V. Parsons, D. A. Ruhl, F. E. Schall, G. R. Smiley, P. H. Winchester, J. J. Yates.

Those who have specialized in the study of factors affecting durability of concrete can today better than at any earlier period point out the main and contributing causes of deterioration of concrete in a structure under examination. Where the deterioration is not pronounced or rapid they will generally name as sufficient remedial measures in future work of like kind, more cement, more sand, less water, safe-working consistency, better early curing and, occasionally, better aggregate. This is progress.

A sound knowledge of what to do and of what to avoid if based on a knowledge of cause and effect, must embrace a knowledge of how to duplicate, under like conditions of exposure, any characteristic performance in concrete, good or bad. When we shall have advanced to this state of knowledge and its application in the art, we can look forward with greater assurance to concrete for durability.

Time is a factor in the application of scientific knowledge. It has taken time for interests producing aggregates for concrete to respond to the trade demand for better grading in separate sizes. Producing interests, through their several associations, are alert to the demands of the trade and disseminate to their membership and to the engineering profession knowledge acquired from research and experience. The individual producer must respond to the higher standard requirements for cleanliness, sizing and grading. The increasing use of the dry batching by weight at central

plants and the use of ready mixed concrete proportioned by weight, through which uniform consistency can be better controlled than when volumetric measurement is used, are welcomed as aids to better concrete making. Batching by weight on the job is an improvement over batching by volumetric measurement. The art is following the science more closely today than ever before.

A review of the 1930 report of this Committee, Appendices B and C, is recommended. In many respects it is a cross-section of what is today the last word in basic principles and quality control. Progress in the art over the last two years as applied to construction in typical railroad structures has been gratifying very largely because of the acceptance of basic principles earlier promulgated and their more general application in construction.

Of outstanding importance in this period is a better appreciation of the extent to which unsound aggregates have contributed to the deterioration of concrete, and a better general knowledge of how to select satisfactory aggregates.

The sodium sulfate test is an indication of the durability of aggregates but should be considered only as a guide in their selection. It should not be used as an arbitrary basis for acceptance or rejection without taking other factors into account. Results obtained with a particular material when exposed to actual weathering conditions should be given greater consideration.

Under "Selection of Aggregates" details of tests for soundness are given. A particularly important feature of this report is that it relates the various tests to the behavior of the aggregate in the structure and to the weathering of the rock in the quarry from which the aggregate was obtained. This furnishes a tie-up between methods of testing aggregates and their action in the structure. It shows the importance of including examination of the quarry both as to resistance to weathering and to the vital variation of quality evidenced in parts of the same quarry.

SELECTION OF AGGREGATES

A study of concrete in service reveals that its durability is affected greatly by the durability of the aggregate.

This report shows some serious effects of unsound stone when used as aggregate in concrete. It also presents tests developed to determine their suitability and ties up the section of aggregate in concrete with the effect of weathering at the source.

Disintegration due to unsound aggregate is usually recognized by large pattern or "map" cracking and by "pop-outs" at the surface of the concrete. An examination of such concrete shows the aggregate to be cracked in several directions, or split into thin layers, depending on the character of the stone. Poor quality flint or chert may be recognized by its angular cracking despite its hardness. Thinly bedded sedimentary rocks, such as sandstones, limestones and shales, may be recognized by parallel cracking. Ochre, clay lumps, clay ironstone and similar materials manifest their presence by pop-outs or holes. These effects may be sufficient to fracture small sections. They are initially caused by freezing of saturated non-durable materials resulting in cracks which allow more moisture to enter causing continuing deterioration at a rapid rate.

The accompanying photographs illustrate disintegration caused by unsound aggregate of the cherty type:

Fig. 1. A bridge pier in eastern Kansas in which an unsound cherty limestone was used. The concrete is 20 years old and shows "map" cracking which has progressed from the bridge seat downward with no disintegration at the ground line. The disintegrating area shows numerous "pop-outs" from chert. It is interesting to note that there is no disintegration where the pier is protected from rain by the ballasted bridge deck.

Fig. 2. A close-up of a section of the end of the pier shown in Fig. 1, which is typical of disintegration caused by unsound stone. Deterioration has progressed much deeper in the top course which has a hollow "dead" sound when struck with a hammer.

Fig. 3. A wing wall in eastern Kansas. The concrete is 16 years old and shows shallow "pop-outs" of soft limestone in the upper section and deep "pop-outs" of chert in the lower section. Some "map" cracking is visible which locates the position of more deeply embedded unsound stone which has expanded by the action of moisture and frost.

In selecting a suitable stone for concrete aggregate, much can be determined by a thorough inspection of the quarry from which the stone is secured. Its hardness can be determined with a hammer. The presence of chert, shale and fine clay seams can be determined by inspection. An indication of the weathering qualities can be ascertained from the appearance of a ledge exposed for some years in an abandoned section of a quarry, as in Fig. 4 and 5.

The performance of aggregates in an old concrete structure under exposure similar to that of the proposed structure will afford a proper basis for acceptance or rejection of the aggregate.

Fig. 4. A view of a quarry face in eastern Kansas, the source of the stone used in the structure in Fig. 3. The ledge has been exposed for 11 years and is kept wet by the flow from a spring. In this locality there are an average of 85 freezing and thawing cycles per year; the quarry face has a southeast exposure subjecting it to practically all 85 cycles. The stone is considerably broken up and the face spalled in the 11 years exposure.

Fig. 5. A close-up of a section of the above quarry face showing typical limestone disintegration.

In many quarries a part of the rock strata is of good quality while the remainder is of unsound character. In selecting samples for test, samples must be taken from each major stratum, and separately tested in order to determine the quality of each.

Gravels and sands, because of the manner in which they were formed are generally considered inherently sound. Tests, however, show that this is not the case disclosing many to be unsound and unsuitable for use. Cherty and shaly gravels or sands should not be used until proven sound by test.

In making tests of concrete aggregate to determine resistance to weathering, two general methods have been widely used, namely (1) freezing and thawing, (2) accelerated test by wetting and drying with a sodium sulfate solution. The sodium sulfate test has been used for a number of years with considerable success. This method is more severe than actual freezing and thawing but is not infallible. The result of this test affords a good indication of the quality of the aggregate.

During the last few years there has been considerable development in test methods using actual freezing and thawing. When specimens are frozen submerged in water the action is more severe than when saturated and frozen in air. When freezing is accomplished by placing the specimen in a refrigerated room only one cycle per day can be secured. When the specimens are placed in containers in contact or near contact with a freezing brine, from three to five cycles can be secured per day when the specimens are thawed in tap water.

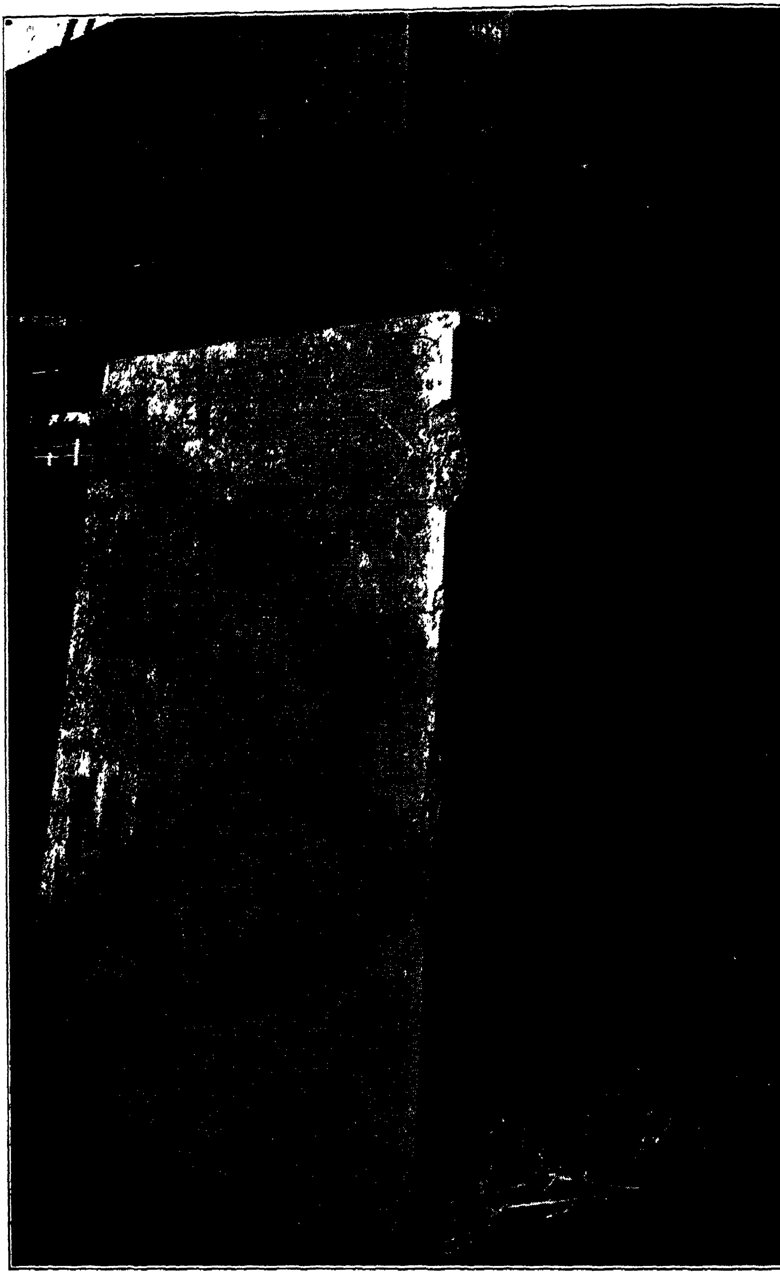

FIG. 1—A bridge pier showing "map" cracking and "pop-outs" from unsound cherty limestone.

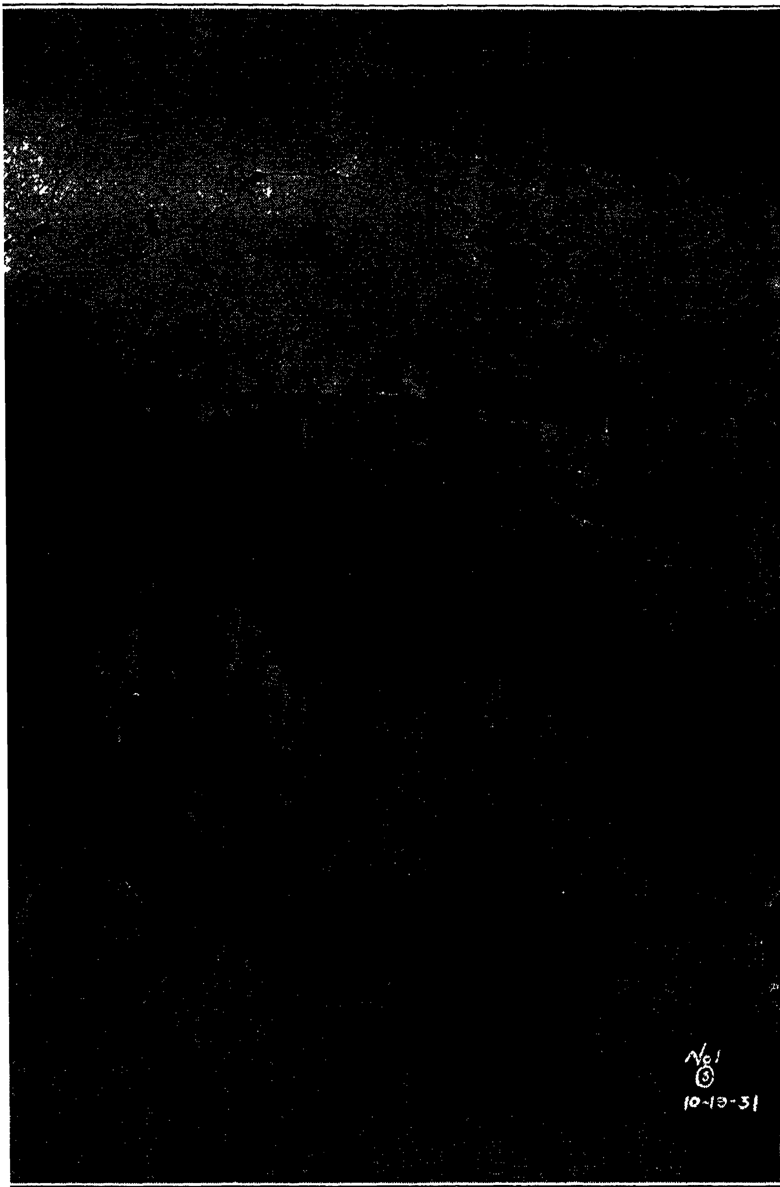

FIG. 2—A close-up of a section of the pier in Fig. 1. This is typical unsound coarse aggregate disintegration.

FIG. 3—A bridge pier in which aggregate from the quarry shown in Fig. 4 was used.

Fig. 4—Limestone ledge showing effects of eleven years exposure to freezing and thawing action.

FIG. 5—A close-up of a section of the ledge shown in Fig. 4.

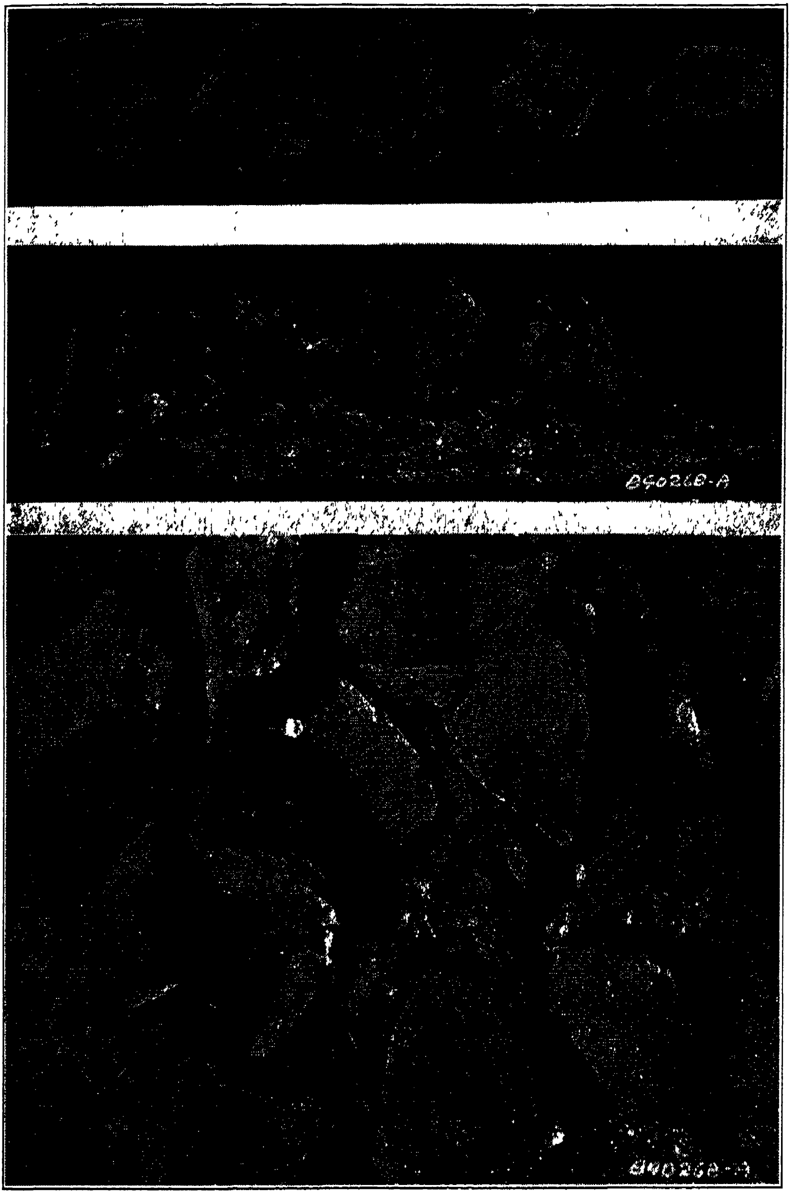

FIG. 6—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 125 cycles freezing and thawing on 10 pieces of stone.

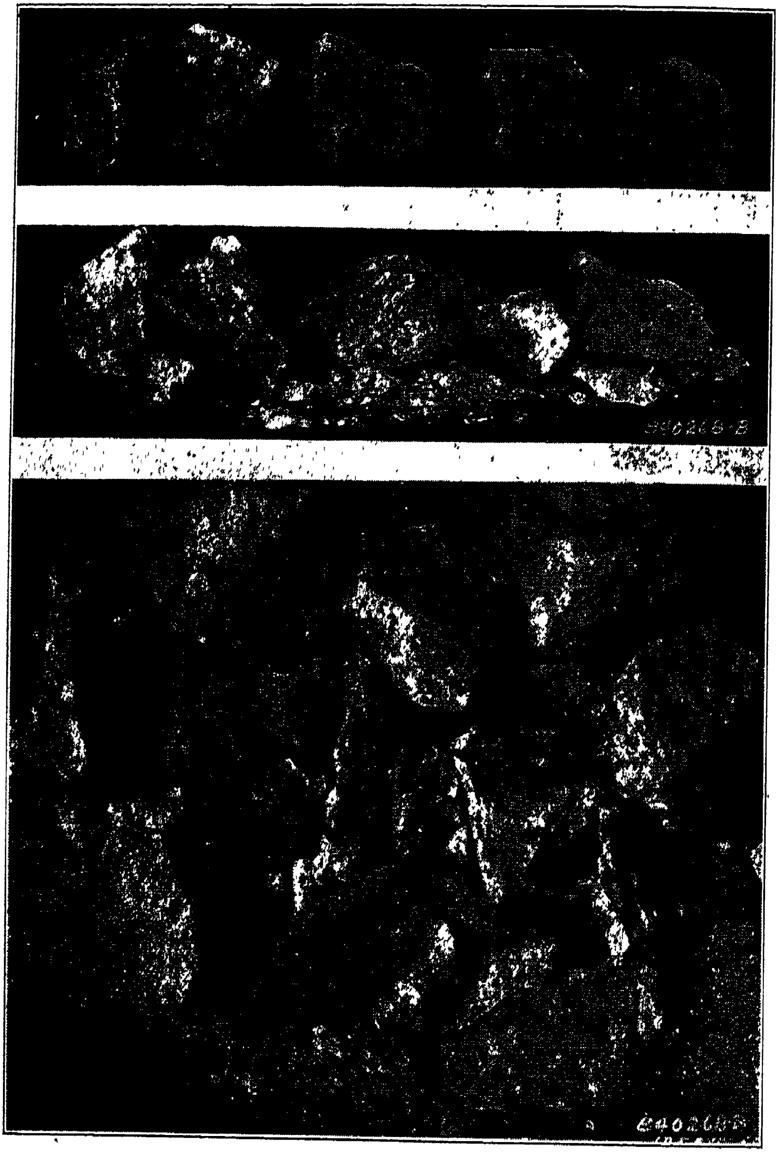

FIG. 7—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 125 cycles freezing and thawing on 10 pieces of stone.

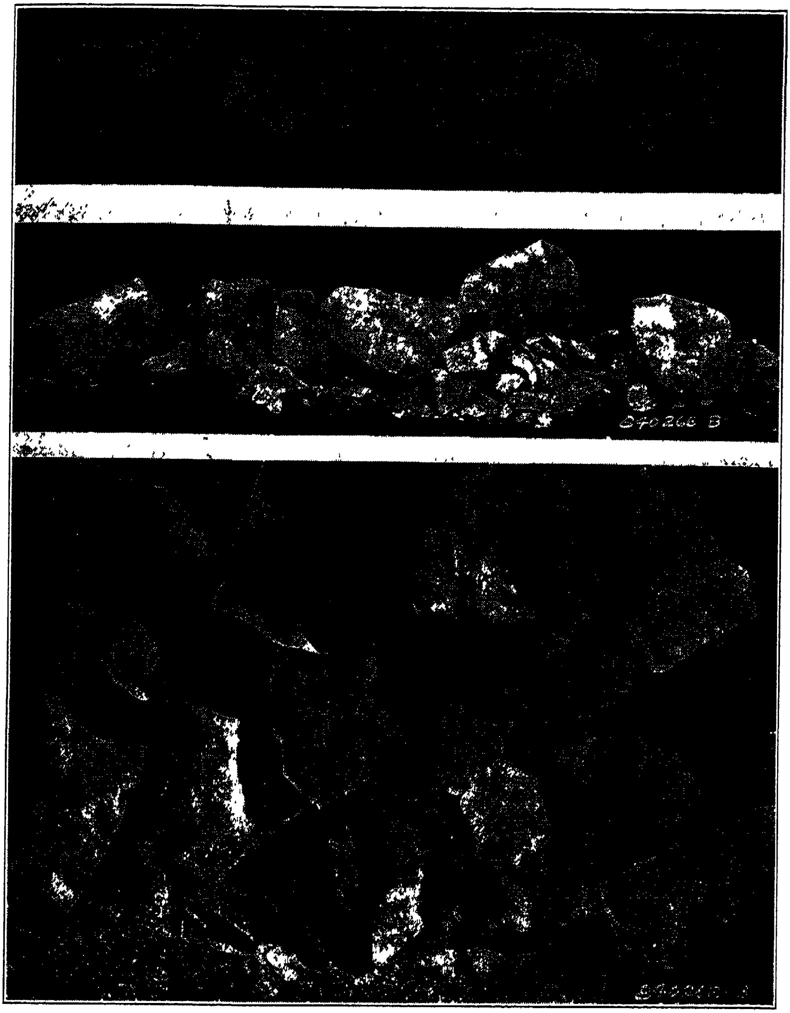

FIG. 8—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 125 cycles freezing and thawing on 10 pieces of stone.

FIG. 9—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 76 cycles freezing and thawing on 10 pieces of stone.

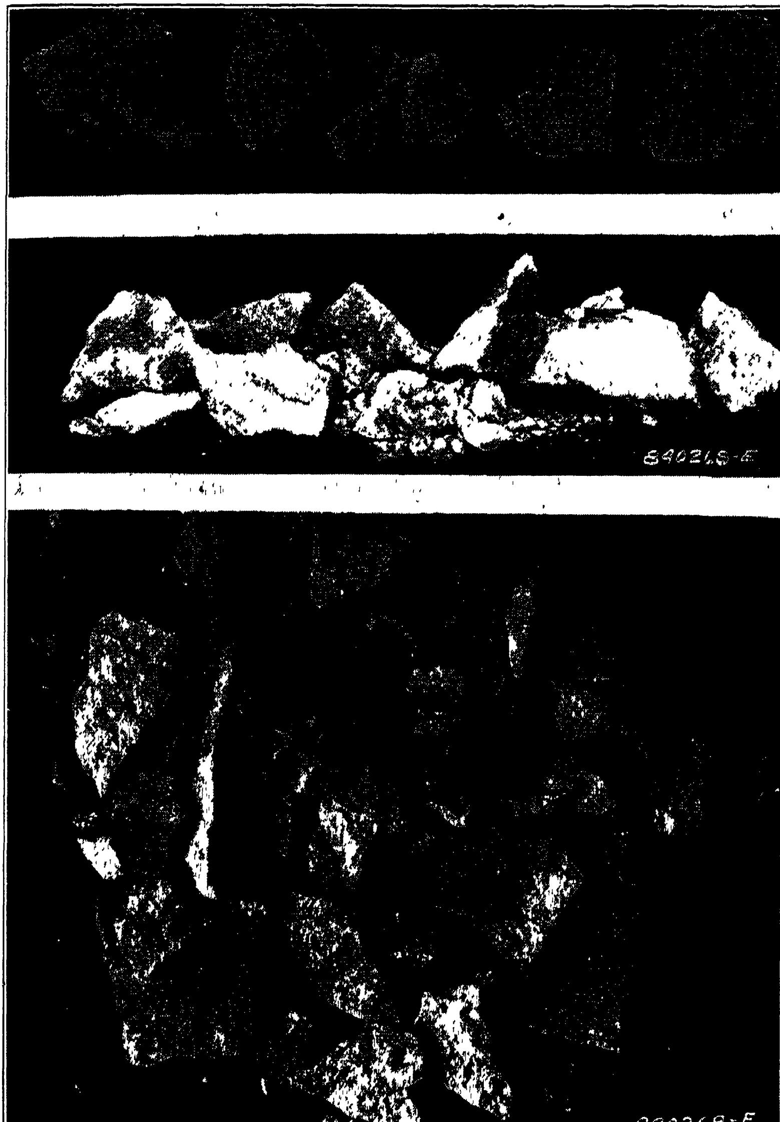

FIG. 10—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 47 cycles freezing and thawing on 10 pieces of stone.

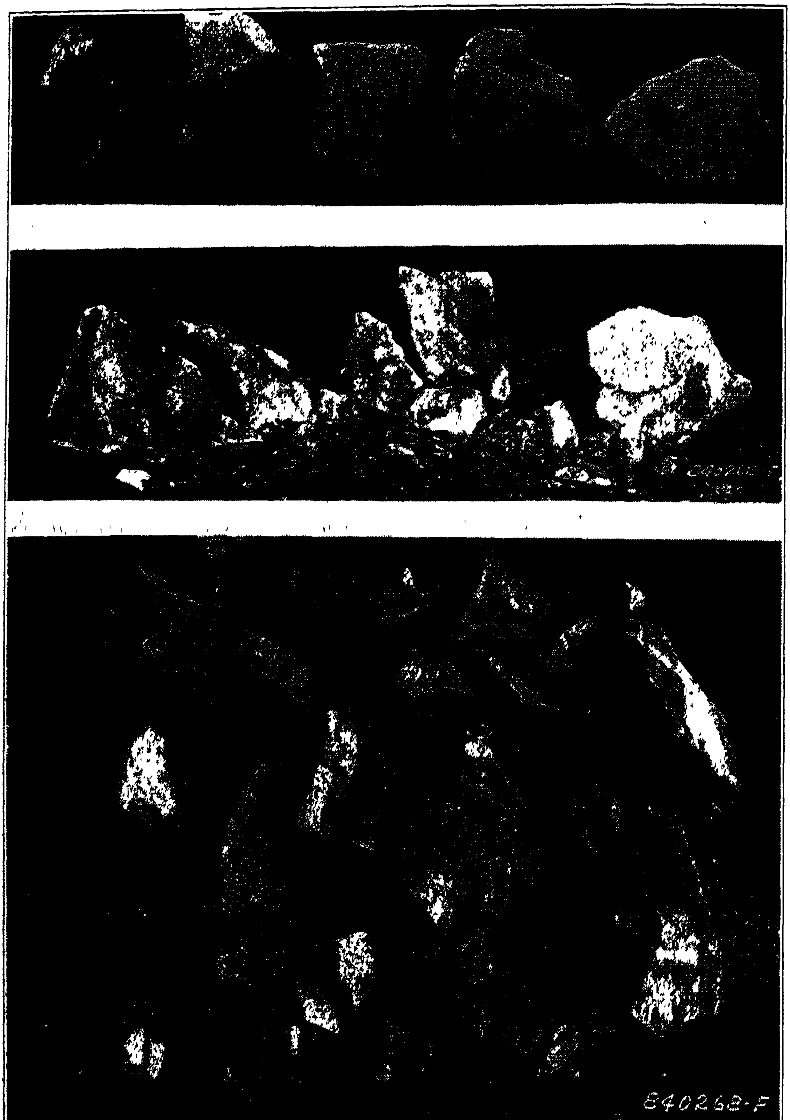

FIG. 11—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 30 cycles freezing and thawing on 10 pieces of stone.

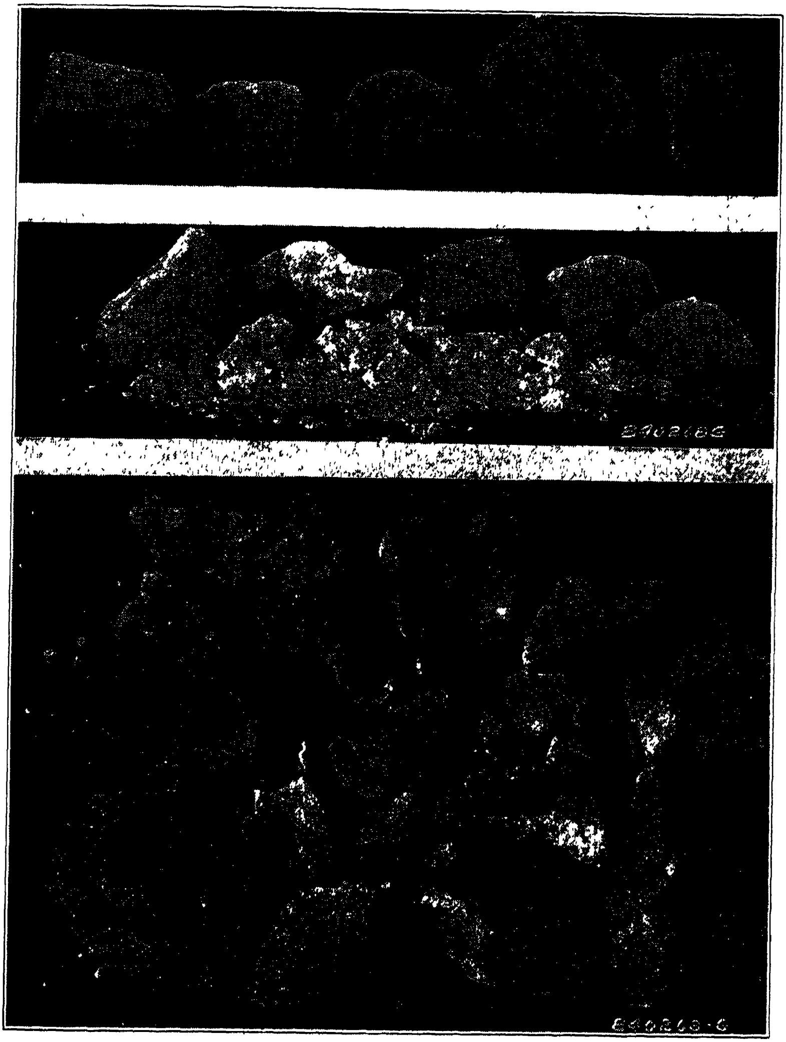

FIG. 12—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 125 cycles freezing and thawing on 10 pieces of stone.

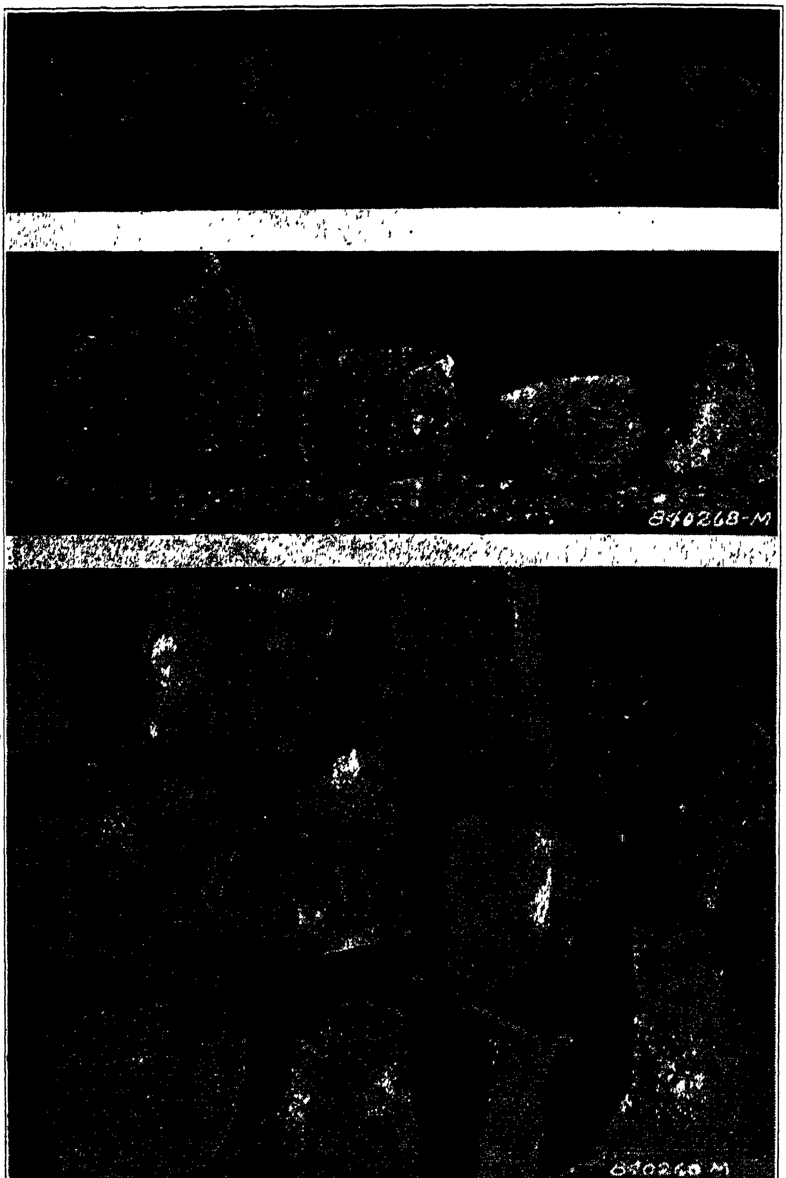

FIG. 13—Top—Before test. Center—After 5 cycles sodium sulphate. Bottom—After 125 cycles freezing and thawing on 10 pieces of stone.

The following test methods using sodium sulfate and by freezing and thawing are suggested:

SUGGESTED METHOD OF TEST FOR SOUNDNESS OF CONCRETE AGGREGATES BY SODIUM SULFATE

COARSE AGGREGATES[1]

1. Scope

This method of test is intended for testing coarse aggregates to determine their resistance to a solution of sodium sulfate.

APPARATUS

2. Containers

Suitable containers for immersing the samples of aggregate in the solution in accordance with the procedure hereinafter described shall be selected. The containers should be non-metallic or of metal not subject to corrosion by sodium sulfate.

Note.—No standard form of container is recommended since different practices will be most convenient in various laboratories, and the Committee does not feel that this question, except for obvious fundamentals, is of importance. Two general methods of immersion have been used as follows:

(1) Each sample placed in a watertight container and covered with sodium sulfate solution.

(2) Each sample placed in a perforated container and immersed in a vat containing the sodium sulfate solution.

3. Temperature Regulation

Suitable means for regulating the temperature of the sodium sulfate solution during the immersion of the samples shall be provided.

4. Weighing Equipment

A balance having a capacity not less than 5000 g., sensitive to at least 1 g., shall be used.

5. Drying Oven

The drying oven shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 105 to 110° C. (221 to 230° Fahr.).

6. Sodium Sulfate Solution

The sodium sulfate solution shall be saturated by dissolving the salt, either of the anhydrous (Na_2SO_4) or crystalline ($Na_2SO_4 . 10H_2O$) form, in water at a temperature of 24 to 27° C. (75 to 80° Fahr.) The solution shall be thoroughly stirred during the addition of the salt and sufficient excess salt shall be added to insure saturation. About 500 g. of the anhydrous form or 1000 g. of the decahydrate will be required for each liter of water. The solution shall be allowed to cool before use to a temperature of 21° C. ± 1° C. (70° Fahr. ± 2° Fahr.).

TEST SAMPLES

7. Samples of Coarse Aggregate

The coarse aggregate for the test shall consist of material from which the sizes finer than the No. 4 sieve have been removed. The sample shall be of such a size that it will yield not less than the following amounts of the different sizes present in amounts of 5 per cent or more:

No. 4 to 3/8-in. size (square openings)	100 g.
3/8 to 3/4-in. size (square openings)	300 g.
3/4 to 1½-in. size (square openings)	1500 g.
1½ to 2½-in. size (square openings)	3000 g.
Larger sizes by 1-in. spread in sieve size	3000 g.

[1] Tentative Method of Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate (A.S.T.M. Designation: C 89-31 T).

Should the sample of coarse aggregate contain less than 5 per cent of any of these sizes, that size shall not be tested but, for the purpose of calculating the test results, shall be considered to have the same loss in sodium sulfate treatment as the average of the sizes tested.

8. Preparation of Test Sample

For making the sodium sulfate test on ledge rock, the sample shall be prepared by breaking it into fragments such that the weights of the fractions specified in Section 7 smaller than 2½ in. may be procured. The mechanical analysis of the entire sample of broken fragments shall be obtained after first sieving the sample through the 2½-in. sieve and rejecting the material passing the No. 4 sieve. The test shall then be made as described in Sections 9 to 14, using the mechanical analysis of the broken fragments for the purpose of weighting the percentages of loss of the several fractions.

The sample shall be thoroughly washed and dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), and separated into the different sizes by screening to refusal. The proper weight of sample for each fraction shall be weighed out and placed in separate containers for the test. In the case of fractions coarser than the ¾-in. sieve, the number of particles shall be counted.

PROCEDURE

9. Storage of Samples in Solution

The samples shall be immersed in the prepared solution of sodium sulfate in such a manner that the solution covers them to a depth of at least ½ in. The containers should be covered to reduce evaporation and prevent the accidental addition of extraneous substances. The immersed samples shall be maintained at a temperature of 21° C. ± 1° C. (70° F. ± 2° F.) for a period of 18 hours.

Note.—A moist room such as is used for curing concrete and mortar test specimens offers a convenient means of controlling the storage temperature. The presence of a few crystals of sodium sulfate in the containers is essential to keeping the solution saturated.

10. Drying Samples After Immersion

After the 18-hour immersion period the aggregate samples shall be removed from the solution and placed in the drying oven. The oven shall have been brought previously to a temperature of 105 to 110° C. (221 to 230° F.). Care shall be exercised to avoid loss of any aggregate particles.[1] The samples shall be dried to constant weight at the specified temperature. After drying, the samples shall be allowed to cool to within the range of temperature permissible for the solution in which they are to be immersed, when they shall again be immersed in the prepared solution as described in Section 9.

11. Cycles

The process of alternate immersion and drying shall be repeated until the required number of cycles is obtained. Unless otherwise specified, five cycles shall constitute a test.

12. Examination

Fractions of samples coarser than ¾ in. shall be examined qualitatively after each immersion and quantitatively at the completion of the test. Fractions finer than ¾ in. shall be examined quantitatively only, and after the completion of the test.

13. Qualitative Examination

The qualitative examination and record shall consist of: (1) observing the effect of action by the sodium sulfate solution and the nature of the action, and (2) counting the number of particles affected.

Note.—Many types of action may be expected. In general, they may be classified as disintegration, splitting, crumbling, cracking, flaking.

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[1] The detritus also should be saved if the complete analysis suggested in the Note in Section 14 (b) is made.

14. Quantitative Examination

The quantitative examination shall be made as follows:

(a) After the completion of the final cycle and after the sample has cooled, the sodium sulfate shall be washed from the sample by means of warm water. This shall be done by soaking the sample in fresh, clean, warm water for approximately one hour, decanting the liquid and repeating this operation at least four times. Materials of high absorption may require a greater number of washings.

Note.—The operator should assure himself that this procedure washes the sample free of sodium sulfate by testing the wash water from each sample. Barium chloride ($BaCl_2$) solution will cause a precipitate if sodium sulfate is present.

(b) After the sodium sulfate has been removed, each fraction of the sample shall be dried to constant weight at a temperature of 105 to 110° C. (221 to 230° F.), weighed and screened over the same sieve on which it was retained before the test. The weight of the material passing the sieve shall be determined and the weight recorded.

Note.—While only particles larger than the ¾-in. size are to be examined qualitatively it is recommended that examination of the smaller sizes be made in order to determine if there is any evidence of excessive splitting.

In addition to the procedure described in Paragraphs (a) and (b) the following is suggested as giving additional information of value: After treating each separate fraction of sample as described in Paragraph (b) all sizes, including the detritus, shall be combined and a sieve analysis made using a complete set of sieves for the determination of the fineness modulus The results of the sieve analysis shall be recorded as cumulative percentages retained on each sieve.

Report

The report shall include the following:

(a) Weight of each fraction of sample before test;

(b) Number of particles in each fraction of sample coarser than ¾ in. before test;

(c) Number of pieces affected, in fractions coarser than ¾ in. only, classified as to number disintegrated, split, cracked, flaked, etc.;

(d) Material from each fraction of sample, finer than sieve on which fraction was retained before test, expressed as a percentage by weight of the fraction.

(e) Weighted average calculated from the percentages of loss for each fraction, based on the grading of the sample as received or, in the case of ledge rock, as prepared by breaking into particles for the test.

Fine Aggregates[1]

The method of test for soundness of fine aggregates by the use of sodium sulfate is identical with that used for testing coarse aggregates excepting paragraphs 7 and 8 pertaining to "Test Sample", the selection and preparation of which are as follows:

Test Sample

7. Sample of Fine Aggregate

Fine aggregate for the test shall be passed through a ⅜-in. sieve. The sample shall be of such size that it will yield not less than 100 g. of each of the following sizes present in amounts of 5 per cent or more, expressed in terms of sieves conforming to the Standard Specifications for Sieves for Testing Purposes (A.S.T.M. Designation: E 11) of the American Society for Testing Materials:[2]

Retained on Sieve No. 50, passing Sieve No. 30
Retained on Sieve No. 30, passing Sieve No. 16
Retained on Sieve No. 16, passing Sieve No. 8
Retained on Sieve No. 8, passing Sieve No. 4
Retained on Sieve No. 4, passing ⅜-in. Sieve

[1] Tentative Method of Test for Soundness of Fine Aggregates by Use of Sodium Sulfate (A.S.T.M. Designation: C 88-31 T).

[2] 1930 Book of A.S.T.M. Standards, Part II, p. 1119.

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Should the fine aggregate contain less than 5 per cent of any of these sizes, that size shall not be tested but, for the purpose of calculating the test results, shall be considered to have the same loss in sodium-sulfate treatment as the average of the sizes tested.

8. Preparation of Test Sample

The sample shall be thoroughly washed on a No. 50 sieve and dried to constant weight at a temperature of 105 to 110° C. (221 to 230° Fahr.), and separated into the different sizes by sieving as follows:

Make a rough separation of the graded sample by means of a nest of the standard sieves specified in Section 7. From the fractions obtained in this manner select samples of sufficient size to yield 100 g. after sieving to refusal. In general, a 110-g. sample will be sufficient. Fine aggregate sticking in the meshes of the sieves shall not be used in preparing the samples. Samples consisting of 100 g. shall be weighed out of each of the separated fractions after final sieving and placed in separate containers for the test.

It is suggested that five cycles of alternate immersion and drying shall constitute a test. A sample shall be considered to have failed when the weighted average calculated from the percentages of loss for each fraction, based on the grading of the sample as received or, in the case of ledge rock, as prepared by breaking into particles for the test, is 20 per cent or more of the original sample.

SUGGESTED METHOD OF TEST FOR SOUNDNESS OF CONCRETE AGGREGATES BY FREEZING AND THAWING

1. This method of test is intended for testing coarse and fine aggregates to determine their resistance to the action of freezing and thawing.

Apparatus

2. The apparatus for freezing test shall be a refrigerator having cooling compartments either surrounded by brine or formed by the cooling coils or fins of the freezing unit. The cooling compartments shall be of such size as to have as little air space as possible surrounding the trays in which the specimens are placed. When the maximum number of specimens are placed simultaneously in all compartments, it shall have capacity to lower the temperature below 10° Fahr., within 4 hours. It shall be able to maintain a temperature of 0° Fahr., throughout the space allowed for specimens and shall have facilities for control of this temperature from plus 10° to minus 10° Fahr.

3. A balance having a capacity not less than 5000 g., sensitive to at least 1 g. shall be used.

4. The drying oven shall provide a free circulation of air through the oven and shall be capable of maintaining a temperature of 220 to 230° Fahr.

Test Sample

5. Test samples of either coarse or fine aggregate shall be prepared as outlined in "Suggested Method of Test for Soundness of Concrete Aggregates by Sodium Sulfate".

Procedure

6. The sample shall be saturated by immersion in water 24 hours prior to the initial freezing cycle.

7. Each fraction of the sample shall be placed in a receptacle and immersed in such a manner that the water covers them to a depth of at least ½ inch. The receptacles shall then be placed in the cooling compartments or in direct contact with the

cooling coils or fins of the freezing unit where they shall remain until completely frozen. The minimum temperature to which the samples shall be subjected shall be below 10° Fahr.

8. At the conclusion of the freezing cycle the samples shall be placed in water maintained at 70 to 80° Fahr. until completely thawed.

9. At the completion of the required number of freezing cycles each fraction of the sample shall be dried to constant weight at a temperature of 220 to 230° Fahr., weighed and screened over the same sieve on which it was retained for test, similar to the procedure as outlined in the sodium sulfate test.

Report

10. The report shall include the following:

(a) Weight of each fraction of sample before test;

(b) Number of particles in each fraction of sample coarser than ¾ inch before test;

(c) Number of pieces affected, in fractions coarser than ¾ inch before test;

(d) Material from each fraction of sample, finer than sieve on which fraction was retained before test, expressed as a percentage by weight of the fraction;

(e) Weighted average calculated from the percentages of loss for each fraction, based on the grading of the sample as received or, in the case of ledge rock, as prepared by breaking into particles for the test.

It is suggested that 50 cycles of alternate freezing and thawing shall constitute a test. A sample shall be considered to have failed when the weighted average calculated from the percentages of loss for each fraction, based on the grading of the sample as received or, in the case of ledge rock, as prepared by breaking into particles for the test, is 20 per cent or more of the original sample.

Note.—In the foregoing recommended method for freezing and thawing tests of aggregates, there are several features which will need investigation before a standard can be adopted. These are:

(a) Minimum temperatures necessary for effective results from freezing.

(b) Minimum time required for complete freezing.

(c) Effect of rate of thawing.

(d) Temperature necessary for satisfactory thawing.

(e) The limits of loss in size or the disintegration of the sample to determine failure of the sample.

During the last year a more accelerated freezing and thawing test has been developed in which the specimens are placed in direct contact with brine by means of wire baskets and are thawed in boiling water. The test cycles used in this method consist of five minutes in water at 200° to 212° Fahr., five minutes in water at 35° to 40° Fahr. and thirty minutes in calcium chloride at plus 10° to minus 10° Fahr., which is 40 minutes per cycle or 10 cycles per day. This method is still in the experimental stage but holds promise of becoming a valuable test.

Tests of samples of stone taken from the various ledges of the present working face of the quarry represented in Fig. 4 were conducted similar to those outlined in the "Suggested Methods of Test for Soundness of Concrete Aggregates by Sodium Sulfate and by Freezing and Thawing". Results of these tests are shown in the accompanying photographs. Samples were selected from the top to the bottom of the ledge as represented by Fig. 6, 7, 8, 9, 10, 11 and 12. Samples from an adjacent top ledge which had weathered in the field, but which appeared to be of a different character, are shown in Fig. 13. At the top of each figure is shown five pieces of stone before the sodium sulfate test. In the center of the figure is shown the disintegration after the five cycles

were completed. At the bottom is shown the results of freezing and thawing tests on parallel samples of ten pieces from the same stratum. Freezing and thawing was continued to 125 cycles or until the stone was judged to have failed. The samples shown in Fig. 9, 10 and 11 failed at 76, 47 and 30 cycles respectively. Results of both sodium sulfate and freezing and thawing tests indicate that these three strata are of poor quality. The stratum in Fig. 13 is sound and the others are questionable for use in exposed structures in severe climates. On the other hand this aggregate would be entirely satisfactory for use in unexposed structures in a severe climate and in exposed structures in a mild climate. The location and type of structure should govern to a great extent the quality of an aggregate which will be satisfactory.

The resistance to weathering of an aggregate is the more important characteristic, but there are other qualities, such as: resistance to abrasion, hardness, toughness, cleanness and freedom from deleterious substances; which have an important bearing on the suitability of a material for use in concrete. Tests for these latter qualities are quite well established and have been standardized for a number of years.

Water Cement Ratio as Affecting Watertightness

Primarily the watertightness of concrete depends upon the water-cement ratio used, the consistency, conditions of curing, methods of placing and compacting the concrete and the grading and relative proportions of the fine and coarse aggregates.

The water-cement ratio is generally accepted as the most important factor in contributing to watertightness or to porosity. A better conception of the water-cement ratio in its relation to the porosity of concrete may be had by thinking in terms of the cement-water paste, the extent to which this paste is diluted with increasing water and the amount of free water remaining in the concrete after the hydration of the cement has taken up that part of the originally contained water which combines with the cement to form a solid. The uncombined water occupies space and, upon evaporation, leaves voids in the concrete. Porosity and its related properties, absorption and permeability, invite agents destructive to concrete. Water is a vehicle for chemicals and gases and is in itself a destructive agent through freezing within the pores.

In this connection it should be understood that the water-cement ratio as applied at the mixer may, and oftentimes does, become unbalanced in the structure and that the water-cement ratio with which we must deal as affecting watertightness is that which obtains in the structure immediately before the concrete begins to set and solidify.

Safe Working Consistency and Water Gain

Consistency may be termed safe working when the concrete can be placed and compacted without segregation of the materials and without honeycomb. Even when the consistency may be considered safe working to the extent that segregation of materials other than water does not occur, the tendency of water to work toward the top may set up a wet condition at the top which will require corrective measures from time to time.

When an over-wet condition arises at the top through water gain, any surplus water above the concrete should be drawn off. Doing this, however, is not in itself sufficiently corrective to insure good concrete in the top of the structure or at the top of a day's placing where there is no load superimposed upon it to compress it and squeeze out excess water while in a plastic state. To correct an over-wet condition in the concrete at and near the top, it will be advisable from time to time to place concrete of a drier consistency so that after absorbing rising water it will still not be of a higher water-cement ratio than was designed for the structure. In such cases, for cor-

rective purposes only, the concrete should be made drier by reducing the amount of water per bag of cement without changing the proportions of the other ingredients. To do this successfully, it may be necessary to place concrete sufficiently dry to require tamping to compact it properly, and plant facilities should be such as to permit of properly mixing, conveying, placing and tamping drier concrete for such needs. When water gain has been sufficient to make questionable the quality of the concrete placed or to be placed, corrective measures should be applied immediately. Failing this, the builder should be required to remove concrete of a higher water-cement ratio than is allowable under the specifications.

Curing as Affecting Watertightness

In the light of experience as well as available test data, the conclusion is justified that no more profitable investment can be made in concrete construction, as measured by strength, impermeability and durability, than by proper protection and curing during early periods after placing.

Evaporation of water from concrete at early stages should be prevented. Favorable curing weather alone often accounts for difference in service behavior of concrete of like quality other than as affected by weather conditions.

Recent studies have yielded important information showing the surprising effect of continued moist curing in increasing watertightness and bring out the fact that further increase in watertightness is cancelled when curing provisions are withdrawn and water evaporates from the concrete.

WATER-CEMENT RATIO AND CEMENT FACTOR

More general recognition is being given to the need for designing concrete for durability, with strength as a secondary consideration, providing only that the strength be sufficient to meet the structural strength requirements. Present-day cements give higher strengths at the usual test periods, such as 7 and 28 days, than was characteristic of cements in former years. The gradual but constant stepping up in the early strength-giving quality of cement has had the effect of making obsolete earlier strength curves in their relation to a given water-cement ratio. Under these changing conditions, early strength in concrete has ceased to be a dependable indication of ultimate watertightness and durability. Abnormally low strengths, however, with any given water-cement ratio should prompt immediate investigation to determine the cause and to apply the proper correction. There is grave danger in designing for strength as a measure of durability without regard for the water-cement ratio used. Unfortunately this practice is too prevalent today. It seems necessary in the circumstances that we should indicate not only the maximum allowable amount of water per sack of cement used for any class of concrete, but also, as an additional safeguard, a minimum allowable amount of cement per cubic yard of concrete with any given size of aggregates used. The following table is submitted:

Class of Concrete	*Maximum Allowable Water in U. S. gal. per Sack Cement*	*Minimum Allowable Amount of Cement Sacks per Cu. Yd. of Concrete Maximum Size of Graded Aggregate* 2½	2	1½	1	¾	½ in.	*Expected Minimum Compressive Str. at 28 Days Lb. per sq. in.*
I	5.00	5.9	6.1	6.4	7.0	7.4	8.0	4000
II	5.50	5.5	5.7	6.0	6.6	7.0	7.5	3500
III	6.25	5.0	5.2	5.5	6.0	6.4	7.0	3000
IV	7.00	4.6	4.8	5.0	5.5	6.0	6.6	2500

If the strengths attained fall below those shown, investigation should be made to determine the cause. Obviously, low strength may be an indication of faulty materials, unfavorable temperature, inadequate curing, errors in proportioning or improper making or testing of the test specimens.

Appendix D

(5) FOUNDATIONS

D. B. Rush, Chairman, Sub-Committee; J. T. Andrews, H. I. Benjamin, F. E. Bates, M. F. Clements, W. F. Cummings, Theo. Doll, G. F. Eberly, J. L. Harrington, A. D. Harvey, G. M. Johnson, A. N. Laird, L. F. Ritter, A. W. Smith, G. L. Staley, I. F. Stern, J. J. Yates.

PROCEDURE TO DETERMINE THE SUPPORTING CAPACITY OF SOILS

Plot of Site.—The topographical map should be prepared giving the ground plan of the proposed structure, showing boundary lines, streets or roads and location of adjacent structures that may be affected by the excavation. The type of foundations of these adjacent structures should be indicated.

Investigations.—Investigations should include—

(1) Explorations
  A—Soil Strata
  B—Geology
  C—Hydraulogy
(2) Tests
  A—Field
  B—Laboratory
(3) Inquiries
  A—Excavations
  B—Type, loading and behavior of adjacent foundations.

Soil Strata.—The character and thickness of underlying soil strata may be shown by means of a sounding rod, a boring auger, an earth auger, a calyx drill, a diamond core drill or by open pits.

The number and location of borings depend upon the nature of the foundation. Sufficient borings should be made to determine the nature of the strata, their slope and variations in their thickness. All borings should go at least 15 feet below the level of proposed footings where practicable and should extend to rock for large structures.

A test pit is valuable as an aid in the interpretation of the borings. Samples from borings should be preserved in air-tight containers which should be properly labeled.

Geology.—Determination should be made of the character of the soil strata, the dip and strike of rock strata, location of faults, joints, slips, foldage or cleavage, disintegrated areas, pockets of intruded material and other similar features.

Hydraulogy.—Determination should be made of the height and change in level of the ground water, its natural direction of flow, the drainage of the surface of the site and probable drainage of underground water by future excavations or drains.

Field Test Procedure.—The nearer to full size the test area for load bearing test, the more reliable will be the result of the test, but the local conditions usually limit the loaded area to from one to four square feet.

The load should be held so that the bearing plate will be horizontal and free from vibration. The bearing plate should be at the bottom of the excavation on undisturbed soil on which the footings are to rest. Without these precautions the test is likely to be unreliable and erratic.

The load should be increased by definite increments in equal periods of time and settlement observed after each increment and at definite times between loadings.

The rate of applying the load affects the settlement under a given load. A rapidly applied load causes more settlement than one slowly applied, within a certain length of time.

A material whose weight per unit is known or easily ascertained should be used as the applied load.

The settlement curve, with loads as abscissas and settlement as ordinates giving a visual conception of the settlement should be plotted. This curve will show a gradual settlement phase and then a rapid settlement phase exhibiting at the break a phenomenon analogous to the yield point in steel.

FIELD TEST INTERPRETATION.—Inasmuch as the penetration of the soil by a test plate involves a compressing of the soil directly beneath the plate and a shearing stress on the soil over the deformed depth along the periphery, the supporting capacity of a bearing area depends upon these two factors, the relative values of which depend upon the nature of the soil.

The portion of the load carried by shear around the periphery is actually the same as that carried by compression on the increment of bearing area at a given depth resulting from the lateral spread of the load by virtue of friction in the soil. Theoretically, therefore, the proportion of the load carried by shear at the periphery varies with the coefficient of friction, or the tangent *of the friction* angle. Tests confirm this theoretical principle.[1]

The supporting capacity of a plate or a footing may be expressed by the formula

$$W = A\,p + L\,f \qquad (1)$$

where

W = supporting capacity of footing
A = area of the bearing
p = unit resistance of the soil in compression
L = length of perimeter
f = shear resistance per linear unit.

By considering the relationship between A and L formula (1) can be transformed to the following

$$W = A\left(p + \frac{4}{D}f\right) \qquad (2)$$

where

D = length of the side of a square or the diameter of a round bearing area

As f depends on the friction angle (the angle of spread) the relative value of $A\,p$ and $L\,f$ will depend upon the extent of penetration or sinking. For sandy soils within practical settlements, that is, where the load curve shows the bearing to be below the yield point, relative values are considered to be about one-third of the load as carried by direct compression and two-thirds by peripheral shear. For clay soils these proportions are approximately reversed so that about two-thirds of the load is carried by direct compression and one-third by peripheral shear.

A numerical example showing the application of the above formulae is given herewith.

Let it be assumed that a one foot square bearing supports 9000 pounds with an initial settlement of one-eighth inch.

(a) Case of Sandy Soil

From 1 $9000 = 3000 + 6000$
or $A\,p = 3000$, and $L\,f = 6000$
$A = 1$, $p = 3000$
$L = 4$, $f = 1500$

[1] For small test area on sand, because of the large coefficient of internal friction, the proportion of the total supporting capacity contributed by shear around the perimeter is so preponderant that some observers have erroneously concluded that the supporting capacity actually varies with the diameter ($\sqrt{\text{Area}}$) whereas, for foundation areas of practical size and of comparable proportions, the predominant factor is the area, as common practice has always assumed.

A foundation ten foot square, using formula (2) might be expected to support the following load with the same initial settlement:

$$W = 100\ (3000 + \frac{4 \times 1500}{10}) = 360000 \text{ pounds}$$

(B). Case of Clay Soil

$$9000 = 6000 + 3000$$
$$p = 6000$$
$$f = 750$$

In this case the foundation may be expected to support the following load with the same initial settlement:

$$W = 100\ (6000 + \frac{3000}{10}) = 630000 \text{ pounds}$$

For the sake of simplicity apparently many factors affecting the supporting power of soils have been disregarded and the formula becomes almost purely empirical. The elements of depth in shear, cohesion, internal friction, water content and permeability become factors in this formula only through the effect they have upon the settlement of the bearing plate in the test.

Laboratory tests, frequently conducted on samples of the soil, are of two kinds: (a) physical; strength in compression and shear, internal friction, cohesion, fluidity, permeability, and other structural properties, and (b) mineralogical; both chemical and microscopical studies of the composition of the soil.

The presence of considerable organic matter may be determined by the color, and in bog soils, by the loss-on-ignition method. The sizes of particles may be determined by screening dried samples where the material is granular.

Although in certain tests a fairly definite relation has been found to exist between the strength of a cube cut from a hardpan soil when tested in a laboratory machine and the bearing capacity of the soil *in situ,* not enough data are available at present to warrant any generalization in this respect.

Tests of internal friction and cohesion (or shear) are of value in that they throw light on the relative value of compression and shear in contributing to the supporting capacity of soil. Likewise friction and fluidity are the factors which control the lateral pressures on foundation structures and the minimum depth for foundations. The permeability test also is valuable because the supporting capacity varies fairly directly with the imperviousness of the soil. The specific weight of soil of any type is an approximate index of its supporting capacity.

The determination of the mineralogical composition, the proportion of colloidal material and of mica flakes, tests of the chemical stability of particles, etc., have value insofar as these qualities affect the above physical properties. Inasmuch as soils are extremely variable and heterogeneous in composition, no definite relationships are known to exist between the mineralogical composition of soils and the physical properties. Therefore, laboratory tests of this character are of less significance than are observations made directly on the physical properties themselves. The presence of acid or alkali constituents in the soil, or of decomposable material may indicate a possibility of injurious effect on foundation materials.

Laboratory Tests Have Their Chief Value as Supplementary to Field Tests in That They May Account for the Results of the Latter

Factors Affecting Supporting Capacity: The supporting capacity of soils is dependent upon two elements (a) the resistance of the stratum on which the footing rests and (b) the rigidity of underlying strata within the range of depth affected by

the loading. Each of these two elements is controlled by the character of the soil itself, the amount of water present and the degree to which the material is confined by overlying and surrounding formations.

For this reason, a soil bearing test without borings or other examination of underlying strata is inadequate, and therefore, both bearing tests and probing of formations beneath the soil stratum directly affected should be included in the procedure to ascertain the supporting capacity of soil.

Appendix E

(6) PREVAILING METHODS AND PRACTICES OF LINING AND RELINING TUNNELS

G. F. Eberly, Chairman, Sub-Committee; F. E. Bates, G. E. Boyd, Kennerly Bryan, Jr., M. F. Clements, W. F. Cummings, A. D. Harvey, W. K. Hatt, A. C. Irwin, A. R. Ketterson, J. F. Leonard, O. V. Parsons, F. E. Schall, G. R. Smiley, C. C. Westfall, C. A. Whipple, C. C. Williams.

Your Committee reports progress on the subject of Methods and Practices of Lining and Relining Tunnels, collaborating with Committee I—Roadway, and presents the following summary of replies received in answer to a questionnaire sent to all Class I railroads together with additional information received from foreign railroads. It should be noted that this is a progress report for information only and that the Committee is not prepared at this time to draw any definite conclusions from this tabulated data.

Number of Roads Reporting

Of the 55 replies to questionnaire, representing 187,917 miles of road, 30 roads reported experience, 11 no experience and 14 no tunnels.

Mileage of Railroads and Mileage of Tunnels

	No. Roads	*Miles of Road*	*Miles of Tunnel*	*Miles of tunnel per 1,000 miles of road*
U.S. and Canada	26	141,358	196.49	1.39
Europe	4	19,890	369.25	18.54
	30	161,248	565.74	3.51

The European group has 17.15 miles more tunnel per 1,000 miles of road than the American group.

The European group embraces the following countries:

	No. Roads	*Miles of Road*	*Miles of Tunnel*	*Miles of tunnel per 1,000 miles of road*
England	2	13,430	199.72	14.87
France	1	4,670	68.31	14.63
Switzerland	1	1,790	101.22	56.55
	4	19,890	369.25	18.54

Standard or Typical Sections

Of these 30 roads, 15 have standard or typical sections of tunnels. On a number of the other roads special sections are used to meet the particular conditions of each case. Eight roads approve of the tunnel sections as shown in the Manual; 2 approve except that track centers should be increased to 14 feet, and 1 approves except that track centers should be increased to 14 feet and that on heavy ascending grades where tunnels are over 200 feet long, the vertical height above top of rail should be 24 feet; 12 do not approve (one European road), and 7 are non-committal (3 European roads).

Kind of Linings

Twenty-one roads use concrete, 1 concrete block or concrete, 1 concrete side walls with brick arches; two brick and stone and 5 brick. The English roads use brick exclusively, the French brick and stone, and the Swiss concrete blocks or concrete. From answers to the questionnaire and the other sources of information, it appears to be the general practice in the United States and Canada to use concrete in new construction and in the installation of permanent linings in existing tunnels.

Method of Placing Concrete

The concrete, in most instances, is mixed near the portal, hauled into the tunnel in dump buckets on a high car and chuted into the sidewalls. The arch concrete is placed with a pneumatic placer located on the car or near the forms. In some cases concrete is placed pneumatically in both sidewalls and arch through a pipe leading from a pneumatic placer at the concrete plant.

Removal of Timber

In new construction 6 roads remove all temporary timbering, 7 remove where formations permit and 12 leave timber in place and partially encase in permanent lining. Five roads report no experience.

In the installation of permanent linings in timber lined tunnels, in most instances the old timber lining is removed to provide required clearance and temporary timbering installed. Seven roads remove all timber; four roads remove where formation permits and 9 leave in place and partially encase. Ten roads report no experience.

The general practice of the European roads reporting is to remove all timber in new construction and in the installation of permanent linings in timber lined tunnels.

Special Facing

Seven roads use special facing for tunnel linings. Three of these 7 apply a special facing of brick to both arch and sidewalls, and 4 roads apply to arch only, 1 of these using Ironoxide method, 1 cement plaster and 2 vitrified brick. The English roads use a Staffordshire blue brindled brick for facing both sidewalls and arch. The French road uses a cement plaster on the upper part of arch only.

Prevention of Seepage

Six roads have used waterproofing in tunnels and of these the majority report that it is not the general practice. Five roads have been successful in preventing seepage by waterproofing by the following methods:

(1) Admixture of hydrated lime in concrete
(2) Open cut tunnels—Asphalt (England)
(3) Cement plaster (France)
(4) Membrane waterproofing
(5) Asphalt over top of arch (Switzerland)
(6) Lead plates over top of arch (Switzerland)

The use of waterproofing paper coated with coal tar pitch was not successful. Other methods to prevent seepage that have been used are:

Method	*Number of Roads*	*Successful*	*Not Successful*
Ironoxide Method	1		1
Grouting	4	4	
Cement gun work	3	1	2
Quick setting cement	1	1	
Concrete placed under pressure	1	1	
Weep holes	5	5	

Tile drains in the rear of tunnel linings have been found successful in preventing seepage on 6 roads and not successful on 1.

Packing

Thirteen roads increase the section of lining to include overbreakage at the springing line and haunches of arch, in preference to dry packing. Eleven do not increase the section of lining. In general, the European practice is to increase the section to include all overbreakage.

There is quite a diversity in the kinds of material used for packing, as shown below:

8—Dry rock
1—Dry rock or brick (England)
1—Dry rock or gravel
1—Dry sand or gravel placed pneumatically.
1—Dry sand and earth
1—Brick
1—Cement (France)
3—Dry wood or rock
3—Wood
3—Same material as lining
1—Most available and suitable material

Expansion Joints

In general expansion joints are not used in tunnel linings, other than construction joints from 20 to 50 feet apart. One road installs an expansion joint of asphalt mastic every 20 feet; another tar paper every 50 feet and a third uses tar paper and elastic filler every 30 to 40 feet. Expansion joints other than construction joints are not used on European roads reporting.

Ventilating Shafts

Replies indicate that there are comparatively few tunnel ventilating shafts. One road has 1 tunnel with 2 shafts, lined with vitrified brick. Condition is good after 18 years of service. One road has concrete lined shafts—some disintegration from freezing and thawing; one road has 1 tunnel with brick lined shafts.

One of the English roads has brick lined shafts with 20 to 50 years service, depending on the quality of brick.

The French road reporting lines the shaft with same masonry as tunnel lining and reports no failure in 83 years.

In Switzerland one road lines the shafts with concrete and dresses with cement mortar.

Disintegration of Concrete

Number of Roads	*Replies*
3	None.
5	Not appreciable.
3	Considerable.
2	Some in some of the tunnels.
2	To a varying extent.
1	None in good concrete linings.
1	Very little except due to poor workmanship.
1 (England)	¾ in. in 30 years.
1	In older tunnels concrete not excellent.
1	Large in one very wet tunnel; small in others.
1	None in electrical operation; much in steam operation.
1	Principal trouble in concrete linings.
1 (Switzerland)	Very little in electrical operation. Least in rock masonry.
1	None in reinforced concrete placed by cement gun method.
24	

Disintegration of Brick and Mortar Joints

Number of Roads	*Replies*
1	None.
2	Varying extent.
2	At ends of tunnels due to freezing and thawing.
1	To certain extent but not as bad as in concrete.
1	Considerable in brick arch one tunnel.
1	Small in spots due to poor brick.
1	Large in one wet tunnel.
1	Medium in common bricks; none vitrified bricks; medium in mortar joints.

Number of Roads	*Replies*
1	None, but some effects from blast and separation of first course.
1	Spawling due to freezing and thawing.
1 (England)	In soft brick of early tunnels; none in blue brindled brick.
1 (England)	None in blue brindled brick; life of mortar joints 20 years.
1 (Switzerland)	Mortar joints principally.
1 (France)	Rarely found and then only in small areas.
1	Face course disintegrated and fell out due to freezing and thawing. Blast effects mortar joints.
1	Face course worn and rounded in 35 years but no repairs required.
1	Slightly more in brick and mortar than in concrete, which is very little.
19	

Tunnels Showing No Disintegration

Number of Roads	*Replies*
9	Concrete, 3 to 23 years old.
3 (1-Swiss)	Dry tunnels.
2 (1-England)	Brick, one tunnel 54 years old.
2	Good concrete.
1	Concrete in short and dry tunnels.
1	Vitrified brick; also short concrete tunnels.
1	Five miles brick tunnels; electric operation and little seepage.
1	Concrete except near portals where freezing and thawing occurs.
1 (England)	Short and dry brick tunnels.
1	Brick where not affected by freezing and thawing.
1	Comparatively dry and electric operation.
1 (France)	Good material and no seepage.
1	Good material, no seepage and not exposed to locomotive fumes.
1	None in many tunnels.
1	No tunnels without disintegration.
27	

Disintegration at Points of Seepage

Relative to disintegration being confined to points of seepage, 12 roads, 1 France, report yes; 5, 1 England, no; 2 generally, and 3, 1 England and 1 Switzerland, that disintegration is greater at seepage points.

Locomotive Blast Wearing Action

Number of Roads	*Replies*
7 (1-Eng. 1-Swiss)	None.
3	Considerable erosion.
2	Erosion of old brick linings with limited clearance.
2	Brick lining worn away.
2	Very little.
1	Face course of brick worn away.
1 (England)	None in blue brindled brick; erosion in ordinary brick.
1	With close clearance wears away brick and mortar.
1	Wearing away of brick arch to the extent of four rings.

Number of Roads	*Replies*
1	Principal factor in disintegration of tunnel linings, especially concrete.
1	Brick linings erode little; high clearance.
1 (Switzerland)	¾ in. erosion in few places; not serious.
1	Depends on quality of material.
—	
24	

Action of Gases and Moisture in Locomotive Fumes

Number of Roads	*Replies*
5 (1-France)	None.
4 (1-England)	Very little.
3	Some action; no failures.
3	Contributory.
2	Considerable.
2 (1-Eng. 1-Swiss)	Large factor.
1	Very detrimental to concrete.
1	Yes, where seepage exists.
1	Primary cause combined with seepage in concrete; secondary in brick.
1	Arch over tracks affected.
—	
23	

Effects from Freezing and Thawing

Number of Roads	*Replies*
2 (1-France)	None.
2	None; mild climate.
2 (1-England)	Very little.
2	Contributory.
2	Major cause.
1	Very slight; mild climate.
1	No failure.
1	No failure; some appearance of trouble.
1	A factor.
1	Slight in brick tunnels.
1 (Switzerland)	In short tunnels.
1	Arch over tracks affected.
1	Principal factor, wet sections.
1	Considerable.
1	Considerable at portals.
1	Primary ends of concrete tunnels, and in brick linings.
1	Causes bulging of face course of brick linings.
1	Near portals.
1	End brick tunnels.
1 (England)	Old brick tunnels.
—	
25	

Surface Treatment of Tunnel Linings

Twenty-two roads have not developed any method of surface treatment for tunnel linings. Other replies follow:

Number of Roads	*Replies*
1	Not necessary.
2	Cement gun method recent application.
1	Ironoxide method; not successful.

Number of Roads	*Replies*
1	Diatomaceous earth in concrete to give dense surface.
1 (Switzerland)	Natural or blast furnace cements.
6	

Use of Reinforced Concrete Placed by Cement Gun Method

Number of Roads	*Replies*
2	Limited extent; some success.
1	To some extent; successful.
1	Limited extent; successful.
1	Yes, with fair success.
1	On a number of tunnels; entirely successful.
1	Extensive repairs made under traffic; not successful; two tunnels repaired 1930 with traffic stopped; appears to be successful.
1	20,000 sq. ft. in repairing brick lining; successful.
1	Used to repair brick linings.
1	Brick lining repaired 20 years ago; first application in tunnel repairs.
1	Repaired all brick linings in 1915; successful.
1	Considerable extent recently.
1	516 ft. raw rock tunnel lined with 2 inches reinforced concrete; successful.
1	Extensive use in two very wet tunnels in recent years; successful to date.
1	No, but now preparing to use in repairing brick linings.
15	

Concrete Roadbeds, Inverts and Struts in Tunnels

Twelve roads report no use of concrete roadbeds, inverts and struts in tunnels, or concrete roadbeds without ballast. Other replies follow:

Number of Roads	*Replies*
3	Concrete inverts.
3	Concrete struts.
1	Brick inverts.
1	Concrete and brick inverts.
2	Concrete floors with ballast walls in new tunnels.
2 (England)	Inverts in soft ground.
1	Concrete inverts in soft ground.
1	Concrete roadbeds installed in 1909; failed and use discontinued in 1925.
1 (France)	Stone and concrete inverts.
1	Concrete roadbed without ballast; recent construction.
16	

Tunnel Drainage

Number of Roads	*Replies*
5	None.
1	Tile and metal pipes; concrete and brick gutters.
1	Concrete and tile pipes, and stone boxes, all in center ditch.
1	Gutter in side wall inside tunnel section.
1	Tile pipes through concrete ballast walls which form ditch.

Number of Roads	*Replies*
1	Concrete gutters. Drain pipes under center of track.
2	Concrete gutters along sidewalls.
1	Concrete side gutters with poor success. Wood best for side ditch drainage.
1	Tiles along sidewalls.
1 (England)	Drains on center line of tunnel.
1 (England)	Earthenware pipes in six foot with drains to sidewalls where required.
1	Side gutters and pipe drains special cases.
1	Pipes along sidewalls.
1	Tile pipes and drains between tracks.
1	Concrete gutters along sidewalls.
2	Side gutters with tile, concrete and wooden drainage pipes.
1 (France)	Longitudinal drains.
1	Side gutters.
1	12 in. × 22 in. redwood drainage boxes along sidewalls in single track tunnels and concrete in double track tunnels.
1 (Swiss)	Concrete pipes and concrete ditches.
27	

Inspection of Tunnels

Number of Roads	*Replies*
2	Semi-annually with motor car.
2	Semi-annually and oftener when necessary.
1	Semi-annually and oftener when required. Use special telescopic platform car, equipped with good lights and tapping hammers; hauled by motor car.
1	Semi-annually with special staging on push car.
1	Monthly by tunnel inspector.
1	Every two months; special equipment.
1 1	Semi-annually by Master Carpenter; monthly by Carpenter Foremen.
1	Regular except by regular maintenance forces.
1	Monthly with tunnel car. Lining tapped with rock drills.
1 (England)	Semi-annually. Special inspection with platform wagon fitted with powerful lights. Brickwork tested throughout for hollow places.
1 (England)	Thorough inspection annually and more frequent when necessary. Traveling flat roof inspection wagon with good lights. Lining sounded all around with tapping hammers.
1	Annually and special inspection when conditions require with necessary equipment to make close inspections.
1	Annually with good lights and sounding rods. Special inspection with tower car, good lights and sounding bars.
1	Trackwalker daily. B. & B. Supervisor and District Engineer annually. Special inspection with high car as necessary.
1	Inspection depends on location and kind of lining. Continuous inspection in some timber lined tunnels.
1	Daily by trackwalker. Rock inspection monthly and special inspection when required.

Number of Roads	*Replies*
1	Occasional inspections are made with scaffold car in addition to general inspection by section foremen and roadmaster.
1 (French)	Regular inspection by inspectors.
1	Quarterly inspection by General Tunnel Foreman and annually with scaffold car.
1	Weekly inspection of unlined tunnels by tunnel inspector and special platform car. Entire tunnel is sounded.
1	By maintenance forces working and passing through the tunnels.
1	Quarterly with staging on push car, spot lights, bard and angles.
1	Annually; frame on push car.
1	Frequent inspection from ground.
1 (Swiss)	Roadmaster inspects unlined sections semi-annually and lined sections annually with scaffold car and suitable lights.
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28	

Appendix F

(8) STATE OF THE ART OF REPAIRING DETERIORATING CONCRETE

A. C. Irwin, Chairman, Sub-Committee; J. T. Andrews, F. E. Bates, G. E. Boyd, Kennerly Bryan, Jr., T. L. Condron, H. G. Blanchard, L. V. Haegert, L. F. Ritter, D. A. Ruhl, C. P. Schantz, G. L. Staley, I. F. Stern, G. R. Smiley, L. W. Walter, P. H. Winchester, J. J. Yates.

TENTATIVE SPECIFICATIONS FOR REPAIRING DETERIORATING CONCRETE

1. Scope

These specifications apply particularly to repairs to concrete made necessary or advisable by causes other than overload, settlement, foundation failure or over-stress of any kind due to external forces. Where strengthening as well as restoration of the structure is to be accomplished engineering plans for such strengthening should be made.

2. General

Conditions causing or contributing to deterioration shall be corrected where possible. Deficiencies such as faulty drainage shall be corrected and honeycombed or unusually porous portions shall be densified or replaced and protected.

The water-cement ratio of the new concrete shall not exceed 6 gallons per sack of cement. A lower water-cement ratio shall be used if practicable. Where it is impracticable to work the concrete in the forms by hand, it shall be assisted into place and compacted by vibration.

Thin or feathered edges shall be avoided and the boundaries of the area to be repaired shall be cut square or undercut to a depth of not less than 1 inch.

Abrupt changes in the thickness of concrete patches or encasement shall be avoided.

All loose and deteriorated concrete shall be removed to a sufficient depth to expose sound concrete for a bonding surface.

3. Preparation of Bonding Surface

(a) The bonding surface shall be rough and clean, and loose particles, dust and dirt shall be removed by vigorous brushing with wire brushes, sand blasting or otherwise prior to application of new material. Oil or film of any sort that may reduce the bond of the new material to the old concrete will not be permitted.

(b) The bonding surface shall be maintained constantly wet for a minimum of one hour prior to application of new material. Sufficient time shall be allowed to elapse after the wetting period to remove all surface wetness and to produce a damp surface that is slightly absorptive. The fresh material shall be applied when this condition is obtained. In no case shall fresh material be applied to a dry surface.

4. Bonding (Hand Patching)

Surfaces shall be covered with $\frac{1}{4}$ inch to $\frac{1}{2}$ inch of mortar consisting of one part cement to one part of clean, durable sand applied immediately prior to placement of the body of the new concrete. The mortar shall be of plastering consistency and shall be thrown against the old surface. The mortar shall have been mixed from one to three hours (depending on temperature) prior to using, but shall be plastic at the time of application.

5. Anchorage

Where the repairs are to restore or strengthen the structure or where application of a bonding coat is impracticable, dowels, approved expansion bolts, or other anchorage shall be used where required to hold reinforcement in place. Anchorage will not be required for relatively thin patches in which no reinforcement is used.

Where used to support and position reinforcement only, dowels, expansion bolts, etc., shall penetrate sound concrete of the old structure at least 3 inches. After insertion of the dowels or anchor bolts the holes shall be filled with cement mortar rammed into place or by grouting. The dowel holes and the concrete surrounding them shall be kept thoroughly wet for a period of at least one hour prior to packing or grouting. Anchors shall be set at least two days prior to attachment of reinforcement to them or to placement of concrete, and shall not be disturbed during that time.

6. Reinforcement

Reinforcement shall consist of mesh and/or bars and where dowels or anchor bolts are used it shall be securely fastened to them.

The sectional area of steel reinforcement shall be not less than $\frac{3}{10}$ of 1 per cent of the average sectional area of the new concrete. Where the work extends around corners, the reinforcement shall be not less than 6/10 per cent of the section of the concrete at the corner. Laps at corners shall be carried far enough along the adjoining faces to develop by bond in each face the full strength of the reinforcement or positive mechanical or metallic connections used that will make the reinforcement continuous without loss of tensile strength.

Reinforcement in the old structure that is to be included in the repair work shall be thoroughly cleaned and any important reduction in area shall be supplied with additional reinforcement.

Reinforcement shall be not less than $\frac{3}{4}$ inch from the surface of the concrete placed with cement guns nor less than 1 inch from the surface of concrete placed by hand.

For encasement work where the concrete extends continuously around the structure or member dowels shall be used only if necessary to hold the reinforcement properly in place.

7. Application of New Concrete

(a) Built-up Patch—Vertical or Steep Surface.—The first coat of a built-up patch shall be projected against the prepared surface with force and shall not be troweled, screeded, or disturbed until the next layer of the new concrete is applied. Successive layers of the patch shall be applied if practicable while the preceding one is still plastic, until the requisite amount of concrete is applied. If the thickness of the patching material on vertical or inclined surfaces is such as to cause sloughing, the applied material of the patch shall be allowed to harden in place until it has acquired sufficient strength to prevent sloughing. Excess concrete shall be carefully removed with a sharp tool and the patch brought to the required surface by patting with a wood float or trowel. The cavity may be overfilled and brought to approximate surface by hammering on a board in contact with, but extending beyond the patch. No troweling or working in a direction other than perpendicular to the finished surface will be permitted until the concrete has acquired sufficient stiffness to prevent disturbance of its original position below the surface troweled. All troweling and/or floating of the surface shall be lightly done so as to limit its effect as far as possible to the surface.

(b) Built-up Patch—Horizontal Surface.—The first coat shall be projected against the prepared surface with force and shall not be leveled off or screeded. Successive layers shall be rammed into place until the cavity is overfilled. The consistency shall be dry enough to permit consolidation by ramming.

The patch shall then be further consolidated by hammering on a board in contact with but extending beyond the patch. Excess concrete shall be carefully removed with a sharp tool so as not to drag the surface and the final finishing accomplished by patting and light troweling. The consistency of the concrete shall be such as to permit maximum compaction.

(c) Packing in Forms.—Where restoration is accomplished by ramming the new concrete in between forms and the old surface, the forms shall be sufficiently strong and so braced or held in place as not to be disturbed by the pressure of the new concrete. If possible, the new concrete shall be placed in layers, each rammed solidly into place. In any case the new concrete shall completely fill the space provided and present a surface identical in location with the original. Vibration of the forms in lieu of ramming is subject to approval of the engineer. Vibrators shall preferably deliver not less than 3000 impulses per minute.

(d) Cement Gun Work.—Cement gun concrete shall be a mixture of one part Portland cement and three parts sand free from particles ¼ inch size and over. The sand* and cement shall be thoroughly mixed in a batch mixer of approved type. Not less than 35 pounds per square inch air pressure shall be uniformly maintained in the cement gun while placing the mixed material. This pressure shall be increased for horizontal delivery distances exceeding 100 feet and for vertical distances exceeding 25 feet. The water pressure shall be uniform and not less than 25 pounds per square inch more than the air pressure. The nozzle of the gun shall be directed as nearly as possible at right angles to the surface being concreted.

This concrete shall be applied in as many coats as are required to obtain the desired thickness but not less than two coats shall be placed. The thickness of each coat shall be such that it will not slough or injure the bond with the preceding coat. At least two hours shall elapse between the placement of succeeding coats.

Shooting strips shall be used to obtain true lines, corners and surfaces. They shall be of such design as to allow the free escape of all rebound or excess sand.

* The sand should contain preferably from 4 per cent to 8 per cent by weight of moisture.

All deposits of loose sand shall be removed and if any such deposit be covered with concrete, it shall be cut out and replaced with satisfactory material.

The next to the final coat of this concrete shall be lightly screeded to true lines and surfaces, but the final or flash coat shall not be troweled or worked in any manner.

8. Color

The color of the aggregate and cement for patching or partial encasement shall be selected to produce a color practically equivalent to that of the old concrete.

9. Curing and Protection

The surface of all new concrete shall be kept continuously damp for a period of 7 days, beginning immediately after placement.

Repair work shall not be done in freezing weather nor until the old structure is free from frost. The new concrete shall have a temperature when placed of not less than 50 degrees Fahr., and this temperature shall be maintained during the curing period.

10. Materials and Workmanship

The materials used shall conform in physical properties to the specifications for Portland Cement Concrete, Plain and Reinforced, of the American Railway Engineering Association.

Only skilled and experienced workmen shall be employed on repair work.

DISCUSSIONS

DISCUSSION ON UNIFORM GENERAL CONTRACT FORMS

(For Report, see pp. 65–106)

Mr. F. L. Nicholson (Norfolk Southern):—Our President has already called to your attention the lack of time, and has asked that we speed up. We, therefore, will make no preliminary statement but will present to you the subjects assigned by the Committee on Outline of Work.

Under Revision of Manual, the Committee has no recommendation to make at this time.

The second subject is that of Form of Agreement for the Purchase of Electrical Energy in Large Volume. This will be handled by Mr. W. H. Brameld, Chairman of the Sub-Committee.

Mr. W. H. Brameld (Erie):—The Sub-Committee's report is printed in Bulletin 340, pages 66 to 74. The draft as shown in the Bulletin is not final. A preliminary form was prepared and submitted to the Electrical Section and based on the criticism received a revised draft was made; this is the form as now printed in the Bulletin. This form was again submitted to the Electrical Section, to the Railway Electrification Committee of the National Electric Light Association and to the Bureau of Engineering of the National Electric Light Association and we have received some very helpful criticism and suggestions. We have also been in touch with the A.R.E.E. We are now trying to harmonize the suggestions received and hope by the next convention to have a form that we can submit for approval.

The form as printed in the Bulletin is submitted as information to enable the members of the A.R.E.A. to consider and make constructive criticism and suggestions. As such it is recommended that it be accepted as information.

Chairman F. L. Nicholson:—It is submitted as a progress report, with the recommendation that it be continued.

The President:—Is there any objection to that?

Mr. E. R. Lewis (Michigan Central):—For nearly twenty-five years I have been following the work of this Committee more or less closely, and I have never taken a minute in discussion before, but during that quarter of a century this suggestion has been forming in my mind and therefore it is not quite snap judgment.

The art of writing contracts is based on simplicity of expression, on the clarity of setting down tersely statements of honest, homely horse-sense. Legal intricacies of expression and long involved sentences tend to defeat the purpose of probably 90 per cent of the contracts that are in force today.

In general criticism only of contract forms, I would suggest the use of the commonest possible words. Use preferably words of one syllable. John Bunyan wrote a whole book of words of one syllable. Very few people can do it. Use, also, only short sentences. Break them up, cut them down, make it snappy. There is no reason why that shouldn't be done in a contract. A contract is a bargain and should be plainly stated. Shun any phrases of involved diction. Express each thought concisely and end with a full stop. Do not jumble your words, and do not repeat. It is not necessary in a contract. Do not depend on punctuation to make clear your meaning. It is poor dependence. Plain expressions need few commas.

In my experience I have found that it is best to spend about 10 per cent of effort in forming a contract and 90 per cent of effort in clarifying it and making it short; in other words, in simplification. Anybody can write involved paragraphs of big words, and very few are fluent in simple language.

Contractor John Jones signs contracts. We should be fair to John. Every contract form should be so clear, so simple, so short, and so fair to John Jones that he can read and understand, remember, and enjoy signing it, knowing it to be sound, sensible, fair, and puncture-proof.

The best contract I ever knew of between two railroad companies, which is worth millions of dollars to both of them, unassailable during eighty years, still intact and in force as first written, is expressed on one printed page of 350 short, simple words. In all that time repeated assaults have failed to read anything into it or anything out of it. The original expression and intent of the writers of that contract stand today.

As to this Sub-Committee's form which is offered as information, I take as an illustration the first paragraph on page 67 of Bulletin 342, under Article II, Obligations as to Supply and Purchase. This paragraph consists of 99 words, 8 printed lines, 12 punctuations, 11 expressions of repetition, and 3 compound terms. If I get the drift of the meaning of this paragraph, I would express it as follows: "The power company shall deliver and the railway company shall buy energy to be used as follows"—17 words.

That may not be the best wording. I do not say that it is, but I would ask the Committee to consider it. In other words, the only thing I have to suggest is: Be brief. That is a complete sentence. There is nothing more to say. You all know what it means.

The President:—Has anyone else any comments or suggestions?

Mr. D. J. Brumley (Illinois Central):—I have not read the contract as carefully as the preceding speaker did, but I would like to ask the Chairman of the Sub-Committee what provision is made for changes in price of coal and changes in price of labor. A contract of this sort made at the present time would be based upon rather high prevailing prices for material and labor. A contract of this sort which runs for a long period of time, maybe 15 or 25 years, should contain some provision for adjustments in prices of material and labor.

Mr. W. H. Brameld:—I might say that this proposed form is in the process of being worked up, and there are various criticisms along the same lines which the Sub-Committee is considering. We would appreciate any suggestions you might have being put in writing for the Committee.

As the form is not in its final shape we would be taking up the time of the convention unnecessarily if we go into the details of the form at this time. Some provisions we now have in the form may be entirely different when we present the final form. If any members have any definite suggestions to offer, or ideas, the Committee will be glad to receive them in writing.

Chairman F. L. Nicholson:—The second subject is that of Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project, the Sub-Committee collaborating with Committee XIV—Yards and Terminals. Mr. W. G. Nusz is Chairman of the Sub-Committee.

The President:—Does that answer your question? Has anyone else any suggestions?

Mr. W. G. Nusz (Illinois Central):—The Sub-Committee's report will be found on pages 74 to 103 inclusive. Your Committee submitted to the 1930 convention a preliminary draft of the Form of Agreement for the Organization and Operation of a Joint Passenger Terminal Project, printed on pages 494 to 524 of Bulletin 320. In 1931, your Committee again called attention to the preliminary draft printed in Bulletin 320 and asked for suggestions or criticisms of the form. It received none from the membership except where specially asked. It has continued to study this subject and has been in constant touch with Committee XIV—Yards and Terminals. The latter

Committee has made a number of very helpful suggestions and the two committees are now in accord.

Your Committee now submits a final draft of the agreement, divided into two parts—the first or "Organization Agreement," provides for the creation of a railway company to operate and maintain the terminal; the construction and method of financing it; and the second, or "Operating Agreement," can be fully executed only after the terminal company has been legally created and has authorized its officers to execute the agreement. Both parts must be considered at the same time as constituting one complete agreement.

Your Committee recommends the adoption of this form, as recommended practice and that it be printed in the Manual.

The form of the Organization Agreement will be found starting on page 77. Section 1 on page 78 provides that the companies agree to incorporate a terminal company, execute the agreement for the terminal company and purchase the shares of stock. If there is any discussion we would be glad to have it as the Section numbers are called.

Section 2. The companies agree to turn over the necessary land owned by them for the terminal. It also covers changes in the tentative plans which are made and later submitted to the terminal company. The companies agree to cause additional property to be acquired, if possible, before the terminal company is chartered. After that time, the terminal company acquires the property. The companies agree to keep construction accounts up to the time of the organization of the terminal company showing the cost of the work. These are later turned over to the terminal company as part of its accounts.

Section 3. On request of any company, part of the terminal may be put in operation for it.

Section 4. Payment for capital stock.

Section 5. The agreement is subject to all laws and rules of commissions.

The agreement for the operation of the terminal project will be found beginning on page 81. For the purpose of discussion, I will read the titles of the Sections.

Protection of Rights and Privileges
Exercise of Corporate Power

Article II:
- Appointment of Trustee
- Method of Financing
- Sale of Capital Stock
- Sale of Bonds
- Sale of Notes or Collateral Trust Bonds
- Failure to Approve Bond Issues
- Provisions Protecting Bond Holders
- Bonds—Guaranteed by Companies (all parties to the agreement)
- Funds Advanced for Construction

Article III:
- Issuance of Stock Certificates
- Delivery of Stock Certificates
- Voting Power

Article IV:
- Subscription for Stock
- Method of Payment
- Advance Notice by Terminal Company
- Default in Payment
- Final Payment

Article V:
- Terminal Area
- Direction and Control in Terminal Company
- Control Exercised by Board of Directors

Executive Committee Authorized
Board of Directors to Supervise Terminal
Operating Organization and Control
Companies' Employees Under Supervision of Terminal Company
Employees to Practice Neutrality
Suspension or Removal of Employees
Expansion of Facilities
Equal Representation
Train Schedules and Time Tables

Article VI:
Terms of Conveyance
Special Warranty Deed
Companies' Option to Repurchase
Payment for Companies' Land
Conveyance of Land to Terminal Company
Division of Taxes and Special Assessments
Substitution of Lands

Article VII:
Method of Procedure
Plans and Specifications

Article VIII:
Use Granted to Companies
Reserve for Retirement
Insurance
Companies to Use Terminal Exclusively
Notice of Completion
Failure to Use
Railroad Connections to Terminal
Lease Concessions
Special Service
Terminal Company to Appoint Agents
Check of Agents Accounts
Terminal Company to Maintain, Operate and Manage
Interruptions to Full Use
Charges for Outside Service

Article IX:
Admission of Other Railways (for use of the terminal)

Article X:
Payment by Companies
Records and Accounts
Statement of Expenditures
Subdivision of Records
Rental
Interest Charges
Rents
Taxes and Assessments
Operation and Maintenance Charges
Other Charges
Dividends
Income
Net Rental Apportionment
Payments Before End of Construction Period
Amortization of Indebtedness
User Basis Defined—Passenger Terminal

It was the intention to print the first definition of "User Basis Defined—Passenger Terminal," beginning near the bottom of page 94, in the contract as part of the suggested agreement. This is on a car basis for all parts and facilities of the terminal, and provides for special charges against any company in connection with the equipment terminal, and other facilities where supplies are furnished or repairs made.

The second "User Basis Defined," starting near the center of page 95, is an alternate definition and was intended to be printed in the form of a note. This will be done

when the contract is finally printed. The latter provides for a separate charge for each of the various facilities comprising the terminal based on the use made of the individual facilities, with a charge against any individual company receiving supplies or special services at any of the facilities comprising the terminal.

Page 96:

Payment in Legal Tender
Tentative Monthly Accounting
Inspection of Records
Auditing Committee Appointed
Accounting Practices
Interest on Balances

Article XI:
Partial Destruction of Property
Extraordinary Expenses

Article XII:
Valuations
Valuation Zones

Article XIII:
Loss and Damage—Definitions
Loss and Damage—Liability For
Adjusting Claims for Damage
Reimbursement by Company at Fault

Article XIV:
Default
Payment by Companies Not in Default
No Representation on Board of Directors
Terminal Company Appointed Attorney
Notice to Companies
Breach of Covenant

Article XV:
Assignment of Rights

Article XVI:
Severalty Responsibility
Service of Notice or Demand
No Special Rights or Privileges

Article XVII:
Appointment of Arbitrator
Cost of Arbitration

Article XVIII:
Term of Agreement
Federal and State Laws to Control
Successors and Assigns
Titles of Articles and Sections

The President:—You have heard the motion. Is there a second?

(The motion was regularly seconded.)

Chairman F. L. Nicholson:—The Committee realizes that in a report of this extent, unless the members of the Association have already studied the subject, which was handed to them in the October Bulletin, you could not, by simply the reading of the subheadings, be prepared to enter into any very extensive discussion. This matter was submitted to the Committee in 1930, and it has been considerably revised. It has been handled with a number of railroads, and the Committee feels that it has done as good work as possible. It has collaborated with your Committee on Yards and Terminals, and they are satisfied. The Committee therefore feels justified in asking the Association to adopt this form as recommended practice for inclusion in this Manual, and we therefore make such a motion.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

The President:—The report certainly shows the Committee has done a lot of work to get this in the shape it has. The Committee is to be commended for its work.

Chairman F. L. Nicholson:—The next subject is Form of Conveyance of Title Granting the Right to Construct and Maintain Air-Right Buildings over Railway Property. Mr. O. K. Morgan, who is Chairman of this Sub-Committee, has been ill for quite a long while and is not able to be present today. Mr. Lillie of that Committee will present the report.

Mr. J. S. Lillie (Grand Trunk Western):—The report of this Sub-Committee is found on pages 104 to 106 of Bulletin 340.

Your Committee, charged with preparation of a form as above, made inquiry of the Committee on Outline of Work and was advised to first prepare a Form of Deed covering a fee simple conveyance rather than a form of long-term lease.

We report progress as follows: The field has been canvassed to ascertain past usage and to secure copies of conveyances of air-rights, both deeds and leases. We find the present use of air-rights limited to a few of the larger cities. Comparatively few conveyances by deed are of record—a much greater number of long-term leases are to be found. The prospects appear to be that the number of air-right conveyances will increase rapidly in the future.

As information of the membership of the Association, the Committee has prepared a general statement relative to Air-Rights which it offers for publication in the Proceedings, and recommends that the subject be continued.

The President:—If there is no objection, it will be so ordered.

Chairman F. L. Nicholson:—The final subject is Form of Agreement for Pipe Line Crossings Under Railway Tracks. Mr. Charles Silliman, Chairman of this Sub-Committee, is not able to be present this morning.

The Committee has collected from representative carriers in different parts of the country copies of the forms used by them for pipe line crossings. After a study of these contract forms, which differ by reason of the carriers' different locations, the Committee has prepared a tentative general form. This has been considered at two meetings of Committee XX.

The tentative draft has been submitted to Committee XIII with whom we are to collaborate and contact has been made with the American Petroleum Institute whose views and needs, we are instructed, are to be considered in this connection.

Until the cooperative work is further advanced, your Committee is not prepared to submit its final recommendations.

The form has been completed and is now in the hands of Committee XIII, and a committee of the American Petroleum Institute has shown a very great interest within the last few days, after the form had been prepared. It was the intent of the Committee to submit the form as information, but at the last moment it was decided to hold it out until we could have the conference which they have requested. There does not seem to be any special objection to the form, and I am sure we can get together before our next Association meeting.

Mr. President, that completes the report, except that I would like to say this to the Association: the Committee is always ready to receive from the Association members any suggestions that they may have with reference to any standard forms they think might be desirable. We would be glad if you would bring it before the Committee on Outline of Work or advise the Chairman of this Committee. It can be handled either way. Of course, it is needless for me to say, with the experience you have had with Committee XX in the years past, that we desire to be as useful as possible to this Association.

The President:—The Chair hopes the membership will bear Mr. Nicholson's remarks in mind, and be of the assistance he has requested.

If there is nothing further, your Committee is relieved, Mr. Nicholson, with the thanks of the Association for your splendid work (Applause).

DISCUSSION ON IRON AND STEEL STRUCTURES

(For Report, see pp. 107–108)

Mr. A. R. Wilson (Pennsylvania):—This Committee's report is found in Bulletin 340, page 107.

Your Committee respectfully presents reports covering the following subjects:

(1) Revision of Manual (Appendix A), in which I would call your attention to the first paragraph reading:

"Under the direction of this Committee, General Specifications for Steel Railway Bridges, fourth edition, was issued under date of May, 1931. This edition included all revisions adopted by the Association to the date of issue."

(7) Use of copper-bearing steel for structural purposes (Appendix B). It is recommended that the conclusion in the report be approved for publication in the Manual.

I will call on Mr. Lacher to submit this report.

Mr. W. S. Lacher (Railway Age):—This Committee in its previous reports for several years has presented information showing the value of copper-bearing steel as a means of reducing the corrosion resulting from average as well as some of the more abnormal exposures. In view of this, the Committee feels that this material can be recommended for use as a rust-resisting metal, and offers the following conclusions:

"From results of exposure and service tests, on the use of copper-bearing steel, we recognize its value as a rust-resisting metal, and recommend its use in railway steel structures exposed to corrosive influences."

That is recommended for inclusion in the Manual, and I so move.

The President:—Are there any suggestions, or discussion?

(The motion was put to vote and carried.)

Chairman A. R. Wilson:—This concludes our report.

The President:—Thank you very much, Mr. Wilson. The Chair compliments you and the members of your Committee upon the study and consideration you have given this subject (Applause).

DISCUSSION ON WOODEN BRIDGES AND TRESTLES

(For Report, see pp. 243–257)

Mr. H. Austill (Mobile & Ohio):—Your Committee's report is found in Bulletin 341, page 243. The subjects assigned to the Committee and actions recommended thereon are printed, so I will not read them.

Under Appendix A, Revision of Manual, Mr. Tuthill is absent. We have no revisions of the Manual to recommend, so with your approval we will pass on.

Subject (2), Appendix B, on page 244. Mr. Hawley, the Sub-Committee Chairman, is absent. This is a progress report, and I move, sir, that it be so received.

The President:—Unless there is objection, it will be so ordered.

Chairman H. Austill:—Subject (3), Appendix C, appears on page 244, and will be presented by Mr. Grear, the Sub-Committee Chairman.

Mr. S. F. Grear (Illinois Central):—The report of this Sub-Committee is on pages 244 to 246, Bulletin 341. It follows very closely the report submitted last year, except

that the suggestions have been made into conclusions and put in shape for publication in the Manual. I will read these conclusions:

"1. Materials of the same size for ties and for guard timbers should be used on steel bridges and timber trestles, where the design will permit. This would also be applicable to the hardware.

"2. Timbers of the same cross-section should be used in open deck and ballast deck trestles, where both types are in use on one railroad; also the use of timber of standard cross-section for sills, caps or posts of frame trestles and other structures where the lengths cannot be standardized.

"3. Sizes of material for timber trestles should conform as nearly as possible to the standard commercial size adopted as the American Lumber Standards.

"4. Treated pile stubs should be used for foundations of buildings, eliminating the necessity of carrying stocks of timber for this purpose.

"5. Suitable obsolete timber or timber of odd sizes should be used for mud blocks for frame trestles, platforms, buildings, crib walls, platform curbs and concrete forms. In some cases, it may be advisable to re-work such timber into smaller sizes.

"6. Lumber rejected for other purposes may be used in temporary construction.

"7. When a certain size or class of untreated timber or piling is overstocked, it may be found to be more economical to give it a light treatment for preservation of the sapwood than to attempt to dispose of it or re-work it.

"8. Emergency stocks of timber carried at points other than general supply yards should be treated.

"9. Plans should be prepared with a view of eliminating material which is not standard stock. This is especially important for treated material which must be seasoned before treatment.

"10. The Engineering and Maintenance Departments should examine stock lists periodically and, when special material is to be ordered, determine if substitutions can be made from stock.

"11. The Engineering and Maintenance Departments should keep the Store Departments informed as closely as possible on future requirements.

"12. Store Departments should advise all departments concerned of special stocks or overstocks of materials.

"13. (The wording of this is not exactly right.) Recommended: All departments, such as Bridge, Building and Mechanical, should cooperate with a view of reducing the number of standard sizes and grades of lumber."

The Committee recommends that conclusions 1 to 13 be adopted for the Manual; that the remainder of this report be received as information and that the subject be discontinued.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Chairman H. Austill:—Subject (4), Overhead Wooden or Combination Wooden and Steel Highway Bridges, will be presented by Mr. Hart.

Mr. R. P. Hart (Missouri Pacific):—Report of Sub-Committee (4) will be found on page 246, Bulletin 341.

A large part of this report consists of photographs of bridges built in accordance with plans prepared by this Sub-Committee last year.

I wish to call your attention to the last paragraph on page 246, in which it is stated that the actual cost of some of these bridges is approximately three dollars per square foot of roadway surface. That price is based upon commercial rate transportation and full surcharges. It is very probable that considerable saving could be made in the cost of constructing these bridges at this date, this report having been made several months ago.

The Committee offers this report as information and asks to continue this subject for another year to study other phases of timber and combination timber and steel construction for highway bridges.

The President:—We are a little ahead of our schedule, and would be very glad to have any discussion on the subject that you may have.

Mr. B. R. Leffler (New York Central):—I wish to call the attention of the Committee to some of the pictures from a designing standpoint. I would like to see timber bridges made as economically as possible. Longitudinal bracing, as shown on Fig. 1 and 2, for timber bridges with ordinary overhead clearance, say of 22 feet or thereabouts, is not necessary. From my experience, it is not necessary to put in these longitudinal braces, if the stringers are drifted through the tops of the bents. The tops of these bents are securely held, if the ends of the bridge have parapet walls and solid foundations.

There is a fire hazard. If the side of the cut should have a grass fire, or a locomotive should happen to throw sparks which lodge at the lapping surfaces, fire will get a good start.

I suggest that the Committee consider those features, and not forget that a lot of this timber framing is an inheritance from the old carpenter idea. Old carpenters were prone to use braces when there was no necessity.

Mr. Edwin F. Wendt (Consulting Engineer):—The Chairman of the Sub-Committee used the word "surcharges". I think some statement should be made as to just what that term includes.

Mr. R. P. Hart:—The term includes rentals on equipment on the basis of billing parties other than railroads. There are certain charges for rentals of equipment allowed in our I.C.C. valuation, as I understand it. Those charges are not as high as commercial rate rentals. We all know that from any experience we may have had in renting contractor's equipment. Those surcharges also include 15 per cent for accounting, store expense on materials, and 10 per cent for supervision, use of small tools for labor.

In answer to Mr. Leffler, I would like to say that the design of bridges shown in these pictures is one in which it was felt that longitudinal bracing should be installed on account of new fills being constructed at the ends of the bridge following the construction of the timber work; also, partially due to the fact that these bridges are in central Kansas where wind loads are probably maximum; if not maximum, approaching maximum.

The Committee welcomes this suggestion, however, and will be glad to receive other suggestions. So far, we have not had the benefit of as many suggestions as we would like to have in working out these typical plans, and ultimately we hope to work out a plan which can be adopted for use in the Manual, although you appreciate the fact that that is rather difficult to do because of the many conditions, many different track arrangements, angles of crossing, and so forth.

Mr. B. R. Leffler:—I want to make myself clear on that. I refer to the longitudinal bracing, and it is quite evident to me that this has not much to do with wind. It is the sway bracing at right angles to the axis which keeps the trestle in line. I can hardly understand how wind would affect a structure of this type to any marked extent, in a longitudinal direction.

Mr. R. P. Hart:—To my mind, the longitudinal bracing does serve to make the structure more rigid because it ties all of the posts in the two bents together. I believe in this case it is necessary. It is true here that the main reason for the bracing is to take up any end thrust due to the new fills being placed at the ends of the structure.

The President:—Is there any further discussion?

Chairman H. Austill:—On Subject (5), Design of Standard Wood Trestles for Heavy Loadings, the Committee reports progress.

On Subject (6), Relative Merits of Concrete and Treated Wooden Trestles, the Committee is calling on you for help. The report of this Sub-Committee appears on page 252, Bulletin 341. The report is brief but well worth reading.

The General Committee worked on this subject from 1916 to 1918 inclusive, and

that part of the report which was adopted appears on pages 451 to 458 of the 1929 Manual. This is a live subject, and the Committee is in need of your help.

Mr. Ridgway was unable to attend the convention, but was anxious to make some remarks soliciting information. With your permission, I will read some extracts from a letter from Mr. Ridgway.

"Answering your joint letter of the twenty-fourth, addressed to Sub-Committee Chairmen, I regret to advise that on account of an important grade crossing protection hearing before the Public Utilities Commission of this state on March 15, it will be impossible for me to attend the A.R.E.A. convention this year. I had hoped to confer during the convention with the members of the Sub-Committee and definitely decide on some plan of obtaining the data absolutely essential to a correct analysis and definite conclusions on the subject, but as such conference now seems impossible, it will be necessary to get the consensus of opinion from the members by correspondence.

"In the presentation of the Sub-Committee's report at the convention, I wanted to emphasize the difficulties of obtaining usable and authentic records of cost. Data as to longevity and annual cost of repairs of the concrete structures seem hopelessly unavailable because of the fact that the oldest of these structures have been in service for perhaps less than half the period of their serviceable lives. Realizing therefore the futility of any such data, it will be necessary to arbitrarily fix a limit of the serviceable life of the concrete structure by analogy and logical reasoning but, even so, this course of procedure disposes of only half of the problem, the remaining half being of equal importance.

"The difficulty of setting up this undisposed remainder of the question is to be found in the fact that while treated timber trestles have been in service on many lines for long periods, yet the records of their annual maintenance costs have not been kept by the carriers in such form and authenticity as to be a reliable source of information, especially in the earlier years of the life of those structures still in service. The cost of piecemeal repairs and renewals of the ballast deck treated trestles is vastly different from maintenance costs of open deck untreated timber trestles, and therefore an average annual cost of the maintenance of timber trestles in general would avail us nothing. It would seem therefore that unless accurate information can be obtained as to the annual maintenance cost of some carriers who have used ballast deck treated timber trestles exclusively for the entire period of their serviceable lives, the problem is indeterminate. It is the hope of the Committee that some carriers can be found that have records of this sort or other carriers that have consistently kept records of the maintenance cost of individual ballast deck treated timber trestles from date of installation to the date when nothing of the original structure remains in service. Failing in this, the Committee will be unable to return a conclusion different from that formerly reported to the Association."

Gentlemen, I hope you will come to the aid of this Sub-Committee. If we can get the information, the Committee can give you a worth-while report. If we cannot get the information, we cannot improve on material now in the Manual. Again, I appeal to you if you have any definite cost data on maintenance of treated timber ballast deck trestles, or concrete trestles, let us have them.

The President:—Is there any discussion of that, or any suggestions?

Chairman H. Austill:—Subject (8). Mr. Edwards, Chairman of the Sub-Committee is absent. This is a progress report presented for information. It is a subject that the Committee feels is well worth-while.

I call your attention to the fact that the formula used in the report of this Sub-Committee is not that now in the Manual as recommended practice, but this formula was presented in the hope of bringing out some discussion. The Committee would welcome any suggestions that might be of help on this subject.

The President:—Are there any suggestions, or does anyone want to make any statement?

Chairman H. Austill:—Subject (9) will be presented by Mr. Chevalier, Chairman of the Sub-Committee.

The President:—While Mr. Chevalier is coming to the front, I wish you would bear in mind Mr. Austill's request in connection with the relative merits of concrete and

treated wooden trestles, and try to give him information that will be of value. I feel it is a subject that all of us would appreciate knowing more about.

Mr. C. R. Chevalier (Missouri Pacific):—The report appears on page 255 of Bulletin 341 and is a progress report only, as this is the first time this subject has been assigned.

Briefly, the subject resolves itself into the choice of the most suitable hammer to use, after an investigation to determine the kind of soil, desired length of pile below cut-off, and the kind of pile to use.

The purchase of a suitable hammer for any particular work has not been given much consideration. It has been my experience that a double-acting hammer is not as satisfactory in driving heavy piles as a single-acting hammer of the same rated energy. The Raymond Concrete Pile Company reported the same experience.

I will read the conclusions which are presented as information:

"(1) The hammer should be as heavy as possible without undue damage to a properly cushioned pile.

"(2) For average driving conditions, all kinds of piles, the rated gross energy of the hammer in foot-pounds should be twice the weight of the pile.

"(3) For soft driving to rock, from one to two times the weight of the pile.

"(4) For hard driving, from two to three times the weight of the pile."

A questionnaire was sent out to members of the Sub-Committee, and the results appear in Exhibit A, Appendix G.

Chairman H. Austill:—That concludes the report of your Committee.

The President:—Mr. Austill, you are relieved with an expression of thanks from the Association for the good work of the Committee during the past year (Applause).

DISCUSSION ON CLEARANCES

(For Report, see pp. 109–110)

Mr. A. R. Wilson (Pennsylvania):—This Committee's report is found in Bulletin 340, page 109. Your Committee respectfully submits the following as its report.

Clearance diagrams for Platforms (Fig. 4 and 5).

These diagrams continue the series that this Committee will present from time to time, supplementing Fig. 1, 2 and 3, and Paragraphs (a), (b), (c), (d) and (e), which were presented to and adopted by the Association March, 1931 (Bulletin 337, July, 1931, Revisions and Additions to the Manual, page 109).

Action Recommended: That the clearance diagrams, Fig. 4 and 5, be approved, and the revisions substituted for the present recommendation in the Manual, and that paragraphs (a), (b), (c) and (d) (Bulletin 337, July, 1931, Revisions and Additions to the Manual, page 109) shall also apply to Fig. 4 and 5.

We have received some discussions referring to Fig. 5 where we show a distance of 3 feet 3 inches for the height of a platform serving refrigerator cars with distances less than 8 feet. The Yards and Terminals Committee in their report, presenting it as information, recommended a minimum distance of 3 feet 5 inches. The Clearance Committee believes that 3 feet 3 inches is preferable.

I move that the recommendations as read covering paragraphs (a) to (e) and Fig. 4 and 5 be approved and adopted.

The President:—Is there any discussion of that? We would be very glad to have any suggestions that any member may have, or discussion on this subject.

(The motion was put to vote and carried.)

Chairman A. R. Wilson:—This completes our report, Mr. President.

The President:—Thank you, Mr. Wilson. That is a splendid report (Applause).

DISCUSSION ON ELECTRICITY

(Ror Report, see pp. 111–112)

Mr. Sidney Withington (New York, New Haven & Hartford):—This report of the Committee on Electricity is in the nature of a skeleton report. That is one reason why we have a skeleton Committee here on the platform.

The complete report is published as the report of the Electrical Section in, I think, Bulletin 338. I imagine you have all had a chance to read that. It is somewhat more comprehensive than the report which is presented in Bulletin 340, which is referred to in the present program.

If there is no objection, I will read the synopsis which appears on page 111 under the titles of the various Sub-Committee reports. The Committee, or such members of it as are here, will very much appreciate your thoughts in discussion, comment or criticism. It should be noted that the Committee numbers in Bulletin 340 do not correspond to the numbers in Bulletin 338, as some of the reports are omitted.

(2) Inductive Coordination. Cooperation has been continued with the two Joint General Committees on Inductive Coordination of the American Railway Association and the National Electric Light Association, and the American Railway Association and the Bell System. That is, coordination between commercial power lines and railroad communication circuits and railroad power lines and commercial communication circuits, respectively. Work is progressing on the formulation of so-called "principles and practices," on which construction and operation will be based.

(3) Power Supply. An exhaustive report was presented on (a) steam power available for traction and general power purposes; (b) water power available for traction and general power purposes; (c) internal combustion engine power supply. The last is, of course, less in quantity than the others but it is of vital importance in some cases. The report also contained interesting statistics on electric energy purchased and manufactured by steam railroads, and capacity of generators installed in public utility power plants in the United States.

(4) Electrolysis. The study of electrolysis with the view of including description of measures taken to mitigate electrolysis in connection with the Cleveland Union Terminal and the Delaware, Lackawanna & Western electrifications has been continued, and report is made on the steps taken at the Cleveland Union Terminal electrification.

I presume most of you are familiar, at least in a general way, with the problems of electrolysis. They are somewhat analogous on so-called direct-current electrifications to the problems of inductive coordination on single-phase railroad electrifications.

(5) Cooperation in Miscellaneous Regulations. The negotiations with the National Electric Light Association in the preparation of "principles and practices" for power wire crossings over railroads, with accompanying specifications, have been continued. Also, the formulation of "principles and practices" concerning crossings between railway lines and electric power lines.

This is a subject that is very actively being considered by various regulatory bodies, and your Committee is carefully following the whole situation to protect the railroads from unsafe construction across railroad property.

I might say in this connection that the Association maintains representatives in every state (members of the Association), to keep the Association in touch with any activity on the part of legislatures or public utilities commissions looking toward crystallization of requirements for wire crossings.

(6) Overhead Transmission Line and Catenary Construction. The Committee has considered the preparation of typical pole line construction diagrams with a view to

standardization, but has postponed action. Tentative specifications for copper and bronze trolley wire have been submitted as information. That, of course, is connected directly with railroad electrification and overhead power distribution.

(7) Economics of Railway Location as Affected by Electric Operation. Reference is made to a report of a concrete example to illustrate the application of a theory regarding the selection of electric switching locomotives, prepared by Committee XVI, of the Construction and Maintenance Section. I presume most of you are familiar with that report.

(8) Standardization of Insulating Tape. Specifications for Black Varnished Cloth Tape—Straight and Bias Cut, were presented. That is a detail engineering specification.

(9) Standardization of Insulators. The Committee has kept in touch with developments in connection with Specifications for Porcelain Insulators for Railroad Supply Lines, but no changes are proposed at this time. The American Standards Association is actively engaged in standardization of porcelain insulators, and your Committee has a representative on the so-called "sectional committee." He will keep in touch with the work they are doing, and if it seems desirable to change our recommendations to conform to National Standards, of course we will do so.

(10) Protection of Oil Sidings from Danger Due to Stray Currents. The Rules with above title have been superseded by "Recommended Practice for the Protection of Tracks Used in the Loading or Unloading of Inflammable Liquids from Danger of Fire Caused by Electric Sparks." That includes not only stray electric currents, but the static electricity which is always a potential source of danger in handling volatile, inflammable liquids.

(11) Specifications for Track and Third-Rail Bonds. Proposed specifications for Stud Terminal Copper Rail Bonds are presented. Study has also been given to the contact areas and resistances of welded bonds. Welded bonds, as many of you undoubtedly know, are becoming more and more common.

(12) Illumination. The Incandescent Lamp Standards have been revised and amplified. Floodlighting of railroad yards is reported on and Specifications for Large Tungsten Filament Incandescent Lamps submitted.

(13) Design of Indoor and Outdoor Substations. Under this heading, report is made on (a) substation insulation; (b) working clearances; (that, of course, is very important from an operating point of view as well as from a safety viewpoint); (c) relay protection.

(14) High Tension Cables. Progress is reported on the preparation of Specifications for High Tension Cables. That is, cables over 25,000 volts, on which very little actual standardization has been accomplished by any technical body.

(15) Application of Corrosion-Resisting Materials to Railroad Electrical Construction. The samples for corrosion tests installed at Cedar Hill engine house, New Haven, have been under observation and report on their behavior will be made later. I think the report will be available this coming summer. Additional samples have been installed in Hemphill Tunnel and are to be installed in Lambert's Point pier on the Norfolk & Western in the near future.

As a matter of fact, these latter samples have been installed recently in an atmosphere of salt air as well as the smoke, where most of the coal is loaded from the Norfolk & Western to steamers.

For those who aren't familiar with the report, I will say that the New Haven samples referred to are installed in the smoke jack of an engine house where they are submitted practically continually to the exhaust of steam locomotives when the fires are

being blown. Corrosion is exceedingly severe and a test is therefore easily accomplished, accelerated perhaps on the order of 10 to 1 as compared with normal service conditions.

(16) Form of Power Contract for Large Blocks of Power. Progress is reported on the collaboration with Committee XX, of the Construction and Maintenance Section, in the preparation of a "Form of Agreement for the Purchase of Electrical Energy in Large Volume."

Before submitting the report for approval or acceptance as information, which we plan to do, I am going to ask Mr. D. J. Brumley, who is a valued member of our Committee, to make a few remarks.

Mr. D. J. Brumley (Illinois Central):—The matter I have in mind refers to the publication of certain information compiled by the Electrical Section in the A.R.E.A. Manual, the 1929 issue, on pages 668 to 699 inclusive, which contains a reference to the Manual of the Signal Section, A.R.A. At this point there is a very complete index of all of the matters considered, as adopted by the Signal Section, and this index seems to be of great value to the members of the Association.

In the same edition of the Manual, at pages 1327 to 1328, there is a note reading like this: "The recommendations of the Committee on Electricity will hereafter appear in the Manual of the Electrical Section of the American Railway Association."

It occurs to the members of the Electrical Section and your Electricity Committee that the data worked out and approved by the Electrical Section should be made available to you the same as the data for the Signal Section.

On page 1328 there appears references to the practice related to railways individually, the practice dealing with relationship between railways and industries or individuals which they serve, the practice relating to the manufacture and purchase of railway appliances and materials, and also practices defining relationship between the railroad and its contractors or a public service corporation.

All subsequent Bulletins of the A.R.E.A. referring to the Manual contain no reference to additions or revisions of the Electrical Section Manual.

With a view of giving the members of the A.R.E.A. all the data approved and adopted by the Electrical Section, we request that authority be given to print in the next Supplement to the Manual an index to the Electrical Section Manual, the same as has been done for the Signal Section, and also that this practice be followed each year. The Electrical Section index is not voluminous and will not be a great burden on the A.R.E.A. to publish it complete in the next issue of the A.R.E.A. Manual, and likewise to publish revisions from time to time as they are adopted by the Electrical Section.

I move that the report of the Electricity Committee be adopted.

Mr. C. H. Blackman (Louisville & Nashville):—May I ask if the Committee will give us an expression of opinion as to the necessity of carrying out the recommendations under Subject (10) for oil sidings in small towns in outlying districts where gasoline is unloaded.

We have had considerable discussion with the different oil companies and considerable difference of opinion. I find that the members of the American Petroleum Institute are not unanimous at all in their approval of these recommendations. In fact, the Fire Prevention Committee of the American Petroleum Institute approved the recommendations, while some of the other committees of the Institute are apparently not in favor of it.

Chairman Sidney Withington:—The Committee has felt that the justification for these rules has been based on the number of serious fires which have occurred in handling oil in large quantities from tank cars. I will ask the Chairman of that Sub-Committee, Mr. L. C. Winship, who is here, to answer your question more specifically.

Mr. L. C. Winship (Boston & Maine):—It has been the feeling of the Committee that these rules should be broad, and we have endeavored to make them so. We are not in a position to recommend any exceptions.

We recognize that certain committees of the American Petroleum Institute are perhaps not in agreement with the rules as published, but the work of this Committee has been presented to the Institute, and the Committee has worked very closely with similar committees of the Institute. There has been a degree of agreement which might be said to be exceptional. I think we are as close to them as could be hoped for. Certain details may require certain variations in application, but as far as the Committee is concerned, we are obligated to stand on a broad application.

Chairman Sidney Withington:—Are there any further questions on that subject?

Before submitting the report to the question of vote, I think you will be interested in some further information in connection with the work of Committee XVI, and I am going to take the liberty of asking the Chairman of that Sub-Committee to describe in somewhat more detail the tests which have been carried on under his jurisdiction. Mr. R. P. Winton, of the Norfolk & Western, will describe briefly the installation of samples in particularly corrosive atmospheres.

Mr. R. P. Winton (Norfolk & Western):—There has been quite a little work done in the past on the corrosion of materials suitable for roofing and pipes, but there has been practically no work done so far as we have been able to determine on the subject of corrosion of locomotive smoke.

The Committee has collected a group of samples of every possible material, some of which may be of no particular interest, but we want to make the tests as complete as possible. These samples are in the form of 1-inch round rods 6 inches long, and one set of samples has been placed in the smoke jack in the Cedar Hill engine house of the New Haven Railroad. These samples are all arranged at exactly the same level so that the conditions are as near equal as it is possible to obtain.

The indications at present are that in one year's time we can get a loss in weight of approximately 6 to 10 per cent, so that the tests are very much accelerated. We hope this June to complete these tests and make a final report.

We are also trying to study actual operating conditions, and we have placed another set of these samples in a tunnel which represents actual service conditions where hardware not only for electrification but for other purposes is subjected to the violent corrosion of steam locomotives.

We have also installed another set of samples in Lambert's Point pier on the Norfolk & Western which represents, as nearly as possible, service conditions where we have salt air in combination with locomotive smoke.

By comparing the results of these two service tests with the accelerated tests in the smoke jack, we hope to be able to arrive at a factor which will allow us to predict the approximate life of these various materials under service conditions from an accelerated test in a smoke jack, which should not take more than a year or so to complete.

Some of these results are really very interesting. For example, the statement has been made that copper-bearing steel is very desirable for railroad use. Most of the information that has been collected in the past about copper-bearing steel was derived from copper-bearing steel used for freight cars, and there is no doubt from these tests that copper-bearing steel is desirable for this purpose. The results of our tests, where they are subjected to locomotive smoke, do not seem to bear out these conclusions so far, and I doubt very much if any great additional life can be secured from copper-bearing steel under these conditions. However, we hope, at the conclusion of these tests, to be able to give some definite results on the subject of the use of copper-bearing

steel subjected to severe corrosion in tunnels and similar locations. We hope to be able to make a preliminary report on this subject next year.

The President:—Mr. Winton's remarks are very interesting. I wonder if anyone would like to ask him any questions?

Mr. R. P. Winton:—I might say that this group of samples includes, as I stated before, practically all materials available. Some of these materials are much too expensive and are not economical. Nevertheless, we will have information on practically every available material.

Mr. J. P. Hanley (Illinois Central):—I would like to ask the speaker if he has any means of measuring the degree of acceleration that takes place in the smoke jack as compared with the standard service installation, or how you arrive at that degree of acceleration. This is very interesting.

Mr. R. P. Winton:—What we propose to do is to subject these samples in this smoke jack for a period of two years, and weigh the samples at the end of that time. It is true you cannot quantitatively define the amount of smoke that you get in the smoke jack. Nevertheless, it is a test that can be fairly easily reproduced by simply putting the samples in a smoke jack where locomotives are being blown and where there will be considerable smoke.

The service tests will be continued over a period of possibly five years, and the loss in weight determined. From those tests we ought to be able to get an approximate factor which would indicate the loss in service relative to the loss in the smoke jack. A set of copper and structural steel samples were installed in each location for controls so that the loss of all samples can be compared with the controls.

The President:—Are there any further questions? Thank you very much, Mr. Winton.

Chairman Sidney Withington:—I might say that experiments have been tried from time to time for a number of years on the New Haven in engine house smoke jacks. Compared with the same degree of corrosion in actual service, a fairly approximate ratio on the order of 10 to 1 has been observed. That is, for instance, the cold rolled steel in service on the line has shown about the same amount of loss of weight, very roughly, in ten months as the loss of weight in the engine jack in one month.

If there are no further discussions on this subject, I am going to ask Mr. W. L. Morse, of the New York Central, to tell you, briefly, a little about what he has been doing in connection with following the work of the Federal Government, Department of Commerce, and to some extent the New York state legislature in connection with protecting high structures such as transmission towers, smoke stacks, etc., from airplanes, especially in the vicinity of flying fields and along air routes.

A short while ago the subject came up for discussion, and at Mr. Aishton's request the Chairman of the Electrical Section suggested Mr. Morse as representative of the American Railway Association to follow the proposals that were being made from time to time. I think you will be interested in a few remarks by Mr. Morse on this subject.

Mr. W. L. Morse (New York Central):—Before I say anything in regard to this subject of airplanes and structures that Mr. Withington has referred to, I would like to augment somewhat the remarks of Mr. Winship in regard to the Committee on the Protection of Sidings Used for the Handling of Oils.

The report we have prepared is an engineering report. It is based on giving information that will show safe practice at those sidings, because there has been considerable trouble and there is danger at those sidings.

The engineers of the American Petroleum Institute agree with what we have had to say. There are certain Traffic Managers who do not want to pay any of the expenses,

and there may be some other committees of the Petroleum Institute that think it is perhaps unnecessary, but when you want safe practice the engineers of the Petroleum Institute agree that those rules are a guide for safe practice, and I think that is what the members of the Association should have in mind when they have reference to the rules.

Now, taking up Mr. Withington's assignment to me at this moment, I would say that my work has been in connection with the cooperation of miscellaneous regulations. The Committee has been a sort of watchdog to protect the Association against undue influences from legislation, where possible, relating to transmission lines, particularly where they cross railroads. Because of our connection with that topic, when the legislation began to be proposed as it affected transmission lines in the vicinity of airports or flying routes, I, for that reason, was delegated perhaps to watch out that we were not unduly affected.

The first thing that came to my notice was about a year ago when Miss Eleanor Smith, an aviatrix, who at one time held the altitude record, had introduced in the New York State Legislature a bill that would require the depression of and the placing beneath the ground's surface of all transmission lines within one mile of any airport. When that matter came before the committee of the state legislature, it developed that the principal detrimental effect was going to railroads, because certain railroads, like the New York Central in the vicinity of an airport, the Long Island in the vicinity of several airports, and other railroads that might be in the vicinity of airports most any morning (because airports were being established so fast) would then be called upon to depress any transmission lines they might have within one mile of that airport.

Ordinarily, we do not think of railroads having transmission lines, but they do. They are coming more and more, particularly, I think we will find, in connection with signal work. You will find transmission lines perhaps not of very high voltages, but they are transmission lines just the same, and if you had one within a mile of the vicinity of an airport it would have to go under ground and that, of course, involves a considerable expense and a burden.

Because of the fact that that bill so forcibly struck the railroads, and it was so shown at the hearing, that committee advised Miss Smith to withdraw or have it withdrawn by the party who had introduced it for her and come in with another bill. That was a year ago, and that bill was killed in that way.

In the State of New York this last year there was another bill somewhat similar, but which delegated the power to say whether or not a line should go beneath the ground to the Public Service Commission. That was a better bill because there was a chance to arbitrate and there was a chance to present the facts, and it had to be shown that the existence of the transmission line was a detriment at airports. That bill, however, never got to a committee hearing and the legislature, I believe, adjourned on March 11. At least it was scheduled to adjourn on March 11, so we will not hear anything more from that source for another year.

Another feature of this legislation in connection with airports is that at Washington, through the Department of Commerce, rules and regulations are being put out in regard to the operation of airports, in regard to the operation of signals, structures and landing fields, and gradually it is the effort of those powers at Washington to have those rules and regulations adopted by each state under statute. In other words, it will soon be forced upon everybody by law.

Of course, now the Department of Commerce regulates that in a way by refusing to license any airport unless it has certain requirements, or refusing to license a pilot unless he can fulfill certain requirements, so there is a certain control at the present time

by the Federal Government. But when it comes to actually applying that as to the way in which our airports should be built, that comes pretty near being a state function. So it is hoped that all of these various regulations will become a part of various state enactments.

When those rules and regulations were put out, the representatives were composed largely of manufacturers, the Army, the Navy, and pilots, but when it came to talking about transmission lines and those things, the National Electric Light Association was left out, and other people owning those features were left out. For that reason they stirred the matter up to such an extent that about a year ago the Department of Commerce put out an invitation to various organizations, including the National Electric Light Association, the American Railway Association, and other organizations that would have transmission lines or high towers or telegraph lines (they included the communication lines, too) to come down to Washington and go into the matter with the Department of Commerce. It was for that work I was delegated as a representative of the American Railway Association.

So far we have had just one hearing in Washington. At that hearing it was not shown nor was anything said that was derogatory or detrimental to the rules that had been put out. The main feature was that those who should have had a voice in it have not had a chance to present their side.

From that conference there emanated the organization of a committee which is being called the American Committee, which is going into the matter of presenting the side that should be presented to the representatives of the Department of Commerce in regard to transmission lines, high towers and structures (they have even taken in radio transmitting towers), so that the Department of Commerce can have a complete covery of the subject and recommend standards from the American Committee. Whether it will change the rules or not is another matter. Whether it will affect state legislation or not is another matter, because the Department of Commerce has had conferences at Washington at which delegates from legislatures were present in order to get them to see that there should be legislation enacted to carry out the rules of the Department of Commerce.

Just what progress we are going to make in regard to transmission lines I do not know, because the committee working on it has not as yet made a report to what might be called the large committee—there is a sub-committee doing the work—but that is a matter that is in the mill and will be ironed out. I thank you.

Chairman Sidney Withington:—Mr. President, I think there is a motion before the meeting to accept the report of the Committee on Electricity as information. If there is no more discussion, I would suggest that the motion be put.

(The motion was put to vote and carried.)

The President:—In reference to Mr. Brumley's suggestion, that will be referred to the Board of Direction.

Thank you, Mr. Withington, for your splendid report (Applause).

DISCUSSION ON SIGNALS AND INTERLOCKING

(For Report, see pp. 509–515)

Mr. A. H. Rudd (Pennsylvania):—The Chairman of Committee X is ill in St. Louis; the Vice-Chairman could not get over the Canadian line; the Past-Chairman, who was chosen to present this report, is clearing up storm trouble in the Eastern states; the other Past-Chairman who was asked to present it was too busy, so here we are. I am a third pinch-hitter, and if I strike out, it will be all right.

The first report is Revision of Manual (Appendix A) to be presented by Mr. W. M. Vandersluis, Chairman of the Sub-Committee.

Mr. W. M. Vandersluis (Illinois Central):—The 1929 Manual of the A.R.E.A. contains, on pages 667 to 699 inclusive, a complete index of the Manual of the Signal Section, A.R.A., for the convenience of the members.

The subsequent Bulletins of the A.R.E.A. referring to the Manual contain no references to revisions of the Signal Section Manual, although several are made each year.

With a view to bringing the A.R.E.A. Manual up to date, authority is requested to print in the next supplement to the Manual the index to the Signal Section Manual.

Mr. Brumley brought up this same question in connection with Committee XVIII's report. I presume that will be referred to the Board for action, if approved by your body.

(Past-President Earl Stimson in the Chair.)

Chairman A. H. Rudd:—The next subject is Developments of Automatic Train Control, collaborating with the Automatic Train Control Committee, Appendix B, page 510 in Bulletin 343.

Mr. G. E. Ellis, Chairman of this Sub-Committee, died in Washington, December 17th. He was the Secretary of the Committee on Automatic Train Control, A.R.A., and also the Secretary of the Joint Committee on Highway Crossing Protection. He will be very much missed. An account of his life's work has already appeared in Railway Age.

There has been no material change in the mileage and the number of locomotives equipped during the last year.

I might say that the Pennsylvania Railroad, in connection with its electrification, has extended the use of the cab signal installation from Sunnyside Yard on Long Island to Manhattan Transfer, New Jersey, embracing the entire New York terminal area, and is equipping about ninety electrical locomotives. Some are already equipped and operating in that territory.

The Bureau of Safety has completed its inspections and reports covering the various installations.

On the question of interchangeability, the Committee on Automatic Train Control, A.R.A., is continuing its studies, but owing to present conditions only a limited amount of road work has been done. Locomotives have been equipped for operation over the second order installation of the New York, New Haven & Hartford Railroad over the Union Continuous Stop—Code System, and the Boston & Maine Continuous Stop. The operation of these locomotives will be noted in connection with the Committee's studies of interchangeability.

It was expected that Mr. Ellis would have submitted a verbal report. The matter is progressing slowly forward or backward, or some way, and next year we may know more about it.

The Great Northern Railway filed a petition with the I.C.C. for relief from maintaining and operating its train control installation. The railway was granted a hearing

and testimony taken. Decision is pending at the time this report is being written. Since then, the Interstate Commerce Commission has granted the request of the Great Northern. Similar application of the Northern Pacific is now pending before the Commission.

Increased Efficiency Secured in Railway Operation by Signal Indications in Lieu of Train Orders and Timetable Superiorities (Appendix C).

This Appendix is printed, and I do not believe it will serve any useful purpose to read it at this time. It contains a lot of interesting and perhaps useful information.

Attention is called to page 512, types of installations. Under (d), CTC installations on multiple-track lines for the consolidation of interlocking plants making one CTC station control two or more interlocking layouts. This type of installation fully meets the difficult requirements of a busy terminal railroad with numerous junction points.

While the Pennsylvania is not using the electrical control circuits which are usually connected with centralized traffic control installation, it is combining interlockings in the area of the Philadelphia improvement, installing one interlocker which has 303 levers, the largest in the world, and when we get through four interlockers will take the place of fourteen that we now have in service, and eventually will take the place of sixteen interlockers, with consequent great saving.

The Committee presents some lantern slides in an additional report, which fit in very well with report of Committee XXI—Economics of Railway Operation, especially their recommendation to change double track to single track operation in the interests of economy where traffic has fallen off. This data is compiled by Committee I—Economics of Railway Signaling, Signal Section, A.R.A., and will be presented with other information at the Signal Section meeting in May. This Committee is privileged to have an advance copy and use it at this time.

CENTRALIZED TRAFFIC CONTROL ON THE PENNSYLVANIA RAILROAD

BETWEEN BEN DAVIS AND ALMEDA, INDIANA, REPLACING TRAIN ORDER AND TIMETABLE OPERATION

Economic Results

The Pennsylvania Railroad, early in 1930, placed in service on a 29-mile section of track between Ben Davis and Almeda, Indiana, a centralized traffic control system for train operation by signal indication.

The control machine is located in the Limedale interlocking station, approximately three miles west of the west end of the CTC territory.

Operation in this district was originally by train order and timetable rights, with block stations at Gibson, Summit, Marion and Almeda. When the CTC was installed in connection with APB automatic block signals, these four block stations were abolished and operation accomplished by signal indication which superseded train order and timetable superiority.

Double track extends from Indianapolis to Ben Davis and also from Almeda to Limedale, Indiana; the second tracking of the intermediate section between Ben Davis and Almeda having been postponed on account of proposed extensive line changes and grade revisions.

The traffic on this division consists of nineteen regular passenger trains and an average of eleven freight trains daily. Two of the passenger trains make eight local stops in the territory, while the remainder are on fast schedules covering the CTC territory in 30 minutes eastward and 32 minutes westward.

The passing sidings in this territory include advance tracks at Ben Davis and Almeda, a set of lap sidings at Marion, and a single siding at Gibson and Summit. On account of the grade conditions, serious delays were caused when trains were stopped to enter sidings at Summit and Gibson, so much difficulty being experienced at Gibson that this siding was used only when absolutely necessary. Train movements were operated by timetable and train orders, 40 to 45 train orders being issued daily in this territory.

The solution of this operating problem was to install power-operated switches, which, together with the signals for directing train movements, are controlled from the CTC station at Limedale interlocking.

Summary

Average freight train speed increased 87 per cent or from 16 miles to 30.6 miles per hour.

Gross ton-miles per train-hour increased 89 per cent or from 45,709 to 86,558 gross ton-miles.

Locomotive tractive effort same as before the installation.

Net return on total investment, 28%.

Double-tracking, estimated to cost $3,750,000, postponed.

Cost of Installation and Net Saving

CTC on the P.R.R.

Ben Davis to Almeda, Indiana

1	Total cost of installation	$178,750
2	Gross saving per annum	
	a) Saving in freight train costs	$42,639
	b) Saving by reducing number of block stations	24,174
	c) Total gross saving per annum	$66,813
3	Deductions from gross saving	
	a) Annual expenses and charges for maintenance, operation and interest	16,725
4	Net saving per annum	$50,088
5	Annual return on investment over and above 6 per cent interest charges on total cost	28 per cent

Note.—The above statement does not take into account the saving due to the postponement of the construction of a second main track, which would necessitate the building of a new right-of-way to eliminate present grades, curves, etc. This would cost approximately $3,750,000, with a resulting 6 per cent interest of $225,000 on the investment and the added maintenance thereof.

PLATE A

Pennsylvania Railroad, C.T.C. installation. Relay house of concrete with telephone for use of trainmen at west end of advance siding at Ben Davis, Indiana, east limit of the C.T.C. section.

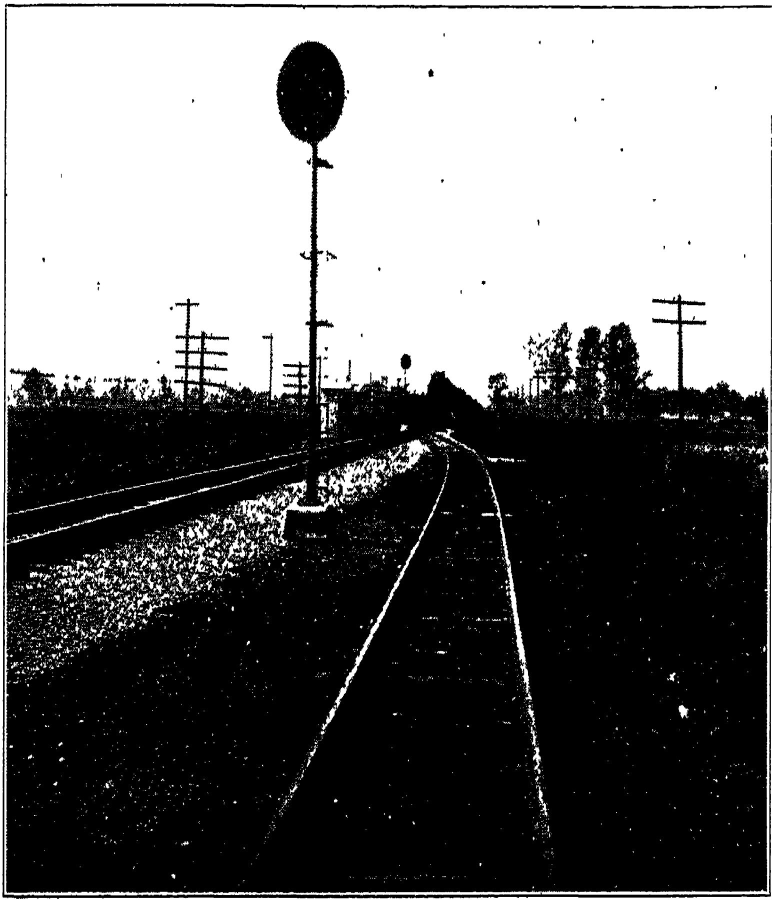


PLATE B

Pennsylvania Railroad, C.T.C. installation. Eastward through freight train at west end of advance siding at Ben Davis. Position light signals and passing siding switch are controlled from C.T.C. station at Limedale.

PLATE C

Pennsylvania Railroad, C.T.C. installation. Westward train No. 65 "American", at west end of Gibson passing siding. Position light signals and passing siding switch are controlled from C.T.C. station at Limedale.

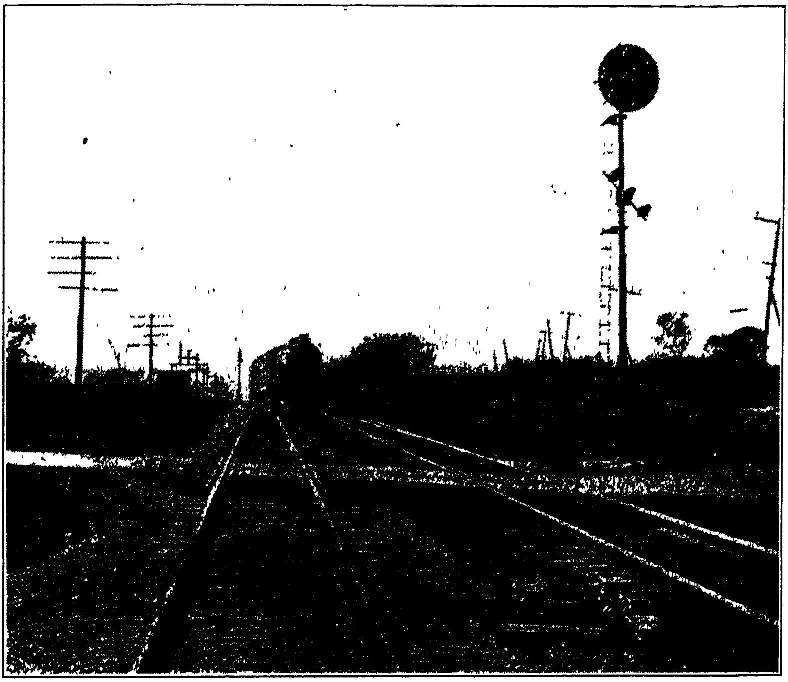


PLATE D

Pennsylvania Railroad, C.T.C. installation. Eastward train No. 66 "American", at east end of double track at Almeda, west limit of the C.T.C. section. Position light signals and crossover switches are controlled from C.T.C. station at Limedale.

Plate E

Pennsylvania Railroad, C.T.C. installation. C.T.C. machine in interlocking station at Limedale. Passing siding switches and signals between Ben Davis and Almeda (29.06 miles) are controlled from this machine, located 3 miles west of Almeda.

CENTRALIZED TRAFFIC CONTROL ON THE MISSOURI PACIFIC RAILROAD

BETWEEN EDGEWATER JUNCTION (KANSAS CITY) AND ATCHISON, KANSAS, REPLACING MANUAL BLOCK AND INTERLOCKINGS

Economic Results

The Missouri Pacific on December 30, 1929, placed in service a centralized traffic control system on 43 miles of single track between Edgewater Junction (Kansas City), Kansas, and Atchison, Kansas. In this territory train movements are now directed by signal indications, superseding timetable superiority and taking the place of written train orders.

In this territory dual control power switch machines were provided at six single sidings, three lap siding layouts, two junctions and one yard entrance switch. At three other sidings the switches are hand operated but signals are provided for directing train movements. Twelve other main line switches leading to house tracks or industry spurs are hand operated and movements to or from such tracks are made on authority from the dispatcher and are protected by signal indication. The operation of the power switch machines and the signals is controlled from a machine in the CTC station at Leavenworth, Kansas.

Physical Characteristics of the Line

Although the traffic is heavy, the large expenditure necessary for the construction of a second track is not justified when other means of increasing the track capacity and expediting train movements are available. The cost of a second track is heavy because the line is built along the Missouri River and in many places is hemmed in by the river on one side and by high bluffs on the other.

The following is quoted from a paper by the Superintendent of the division:

> "Prior to December 30, 1929, trains were operated by timetable, train orders and manual block; there were five continuous and one part-time telegraph office maintained. . . .
>
> "During peak operation, before the centralized control signal system was placed in service, from 130 to 150 train orders and approximately 35 caution cards were issued daily, and it can readily be seen that with the elimination of train orders, the dispatchers can change meeting points and make quick decisions without delay to trains.
>
> "During peak operation, during the time this installation has been in service, we have handled 48 trains in a 24-hour period but have not approached the maximum capacity for operation.
>
> "Our observation has been that approximately 50 per cent of meeting points heretofore resulting in delays are now made without train stops."

About 50 per cent of the meets are now non-stop, resulting in the elimination of about four stops for each through freight train.

The installation of automatic block signals for this territory had been authorized prior to the decision to provide the centralized traffic control system which required an additional expenditure of $130,000.

Summary

Average freight train speed increased 47 per cent or from 13.7 to 20.2 miles per hour.

Gross ton miles per train hour increased 57 per cent or from 47,745 to 74,740 gross ton miles.

Locomotive tractive effort same as before the installation—72,300 lb.

Net return on total investment, 18 per cent.

Double-tracking postponed.

Plate F

Missouri Pacific Railroad, C.T.C. installation. Color light signals at west end of west siding at Oak Mills, Kansas, controlled from C.T.C. station at Leavenworth, Kansas.

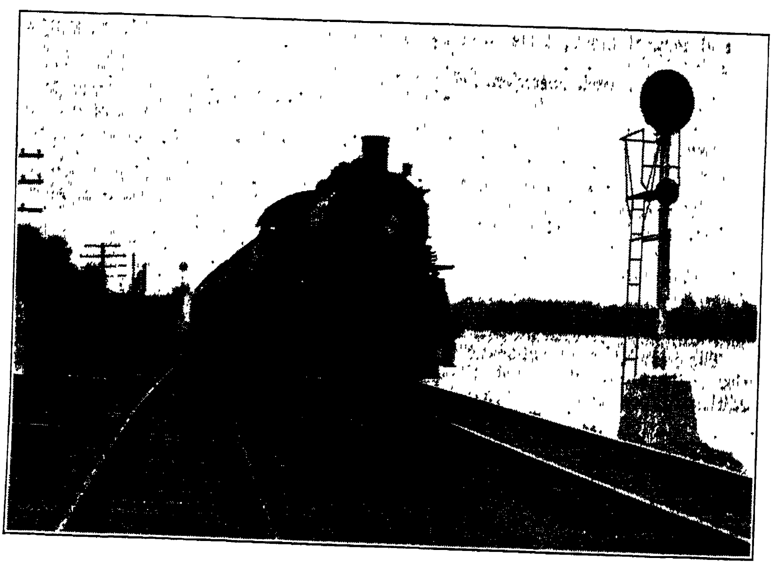


Plate G

Missouri Pacific Railroad, C.T.C. installation. Eastward passenger train No. 104 at west end of Merritt siding. Color light signals controlled from C.T.C. station at Leavenworth, Kansas.

PLATE H

Missouri Pacific Railroad, C.T.C. installation. C.T.C. machine at Leavenworth. The passing siding switches and the signals between Atchison and Kansas City, Kansas (43 miles) are controlled from this machine.

Chairman A. H. Rudd:—The next subject is Appendix D, Synopsis of the Principal Current Activities of the Signal Section, A.R.A., supplemented with List and References by number of adopted Specifications, Design and Principles of Signaling Practice. Mr. Vandersluis will handle that.

Mr. W. M. Vandersluis:—Appendix D covers a synopsis of the principal current activities of the Signal Section, A.R.A. supplemented with list and references by number of adopted specifications, design and principles of signaling practice. By referring to this, you will get a comprehensive idea of what the Signal Section is doing each year.

In connection with Revision of Manual, this will be amplified and cross-indexed so that by reference to the Manual and the Proceedings you will have the complete information.

Chairman A. H. Rudd:—That finishes the report of Committee X.

Past-President Earl Stimson:—Your report is received with the thanks of the Association (Applause).

DISCUSSION ON YARDS AND TERMINALS

(For Report, see pp. 113–147)

Mr. H. L. Ripley (New York, New Haven & Hartford):—The Yards and Terminals Committee was assigned ten subjects, and will make report on seven of them. This report will be found in Bulletin 340, commencing on page 113.

The first section of the report is Revision of Manual.

Before I give that report, I want to thank the members of the Association. Some twenty members have sent in written comments in connection with this Committee's report and made helpful, constructive suggestions to the Committee. I think that is rather unusual. Certainly it is unusual in my experience to have so many take sufficient interest in a report to offer written comment in advance of the meeting of the Asssociation. Those comments and suggestions will be distributed to the members of the various Sub-Committees and will have their careful and thankful attention during the coming year.

The only report we have calling for changes in the Manual is in connection with freight yards. That report will be found on page 114 of Bulletin 340.

Referring to the 1929 Manual, immediately under the caption, "Freight Yards—General," at page 997, the Committee asks to have the following paragraph inserted:

"To meet traffic requirements a yard should be able, even in peak periods, to receive trains promptly upon arrival, perform any auxiliary service (such as icing, feeding and watering stock, making running repairs, etc.), switch cars into their proper classifications without appreciable delay, and dispatch these cars in their proper position in the designated outgoing trains in a minimum of time."

I pause for a moment, if any comment is to be made in connection with this paragraph.

Again, in the same section, at page 1000, in place of a very brief paragraph numbered 47 substitute the following:

"Ice house, stock pens, L.C.L. transfer, etc. should be so located that cars may be placed with minimum delay after arrival and be readily accessible for switching or placement in outbound trains."

The President:—My understanding is that these are to be changes in the Manual. We would like to have any comments, or answer any questions that any of you may have, or hear any discussion on the subject before the matter is put to a vote.

Chairman H. L. Ripley:—In connection with Hump Yards, the Manual, up to date, has made no distinction between that of the rider operated yard and retarder operated yard. There is a very definite distinction in the requirements as between the two yards. A rider operated yard, because of the human element and the judgment that the rider can use, need not be designed with the same particularity as to grades, train resistance, and so forth, as is necessary for the retarder operated yard if operation is to be satisfactory. That, perhaps, is obvious, but I wanted to call attention to it. That study in connection with the requirements of the retarder yard as contrasted with the rider yard has been the work taken up by this Committee for the last two years.

The Committee recommends that the distinction between the two be recognized by rearranging the matter in the Manual. So its recommendation is that, at page 1000, following paragraph 50, insert a heading as follows: "Hump Yards." Then insert the matter following (Bulletin 340, page 114). I will not read it, Mr. President, unless you think it necessary. It has been before the convention for at least two years, and the Committee this year is making no change in the recommendation that it has previously made. I will assume, then, that that has been read and has been found satisfactory.

Following this section, insert a heading, "Hump Yards with Car Riders," and insert the material now appearing in the Manual, pages 1000 and 1001, under that heading, without change.

After the above, and following the typical "Cut List," insert the heading, "Hump Yards with Retarders". This matter, Bulletin 340, pages 115 and 116, is new in the sense that it is presented now for inclusion in the Manual, although it has all been presented for information and discussion in previous reports for the last two years.

The President:—You make a motion to that effect then, do you?

Chairman H. L. Ripley:—I want to call attention to an editorial correction that should be made. You will notice that near the bottom of page 115 there are quotation marks before each of those sub-paragraphs, and again on page 116. Those quotation marks, in editing the matter, should be omitted.

I move that the matter as submitted for revision and inclusion of the new material be placed in the Manual as recommended practice for this Association.

The President:—Gentlemen, you have heard the motion. Is there any discussion?

(The motion was put to vote and carried.)

Chairman H. L. Ripley:—The next report is in connection with Produce Terminals. That report will be found on page 116, Bulletin 340. Mr. E. T. Johnston, Chairman of the Sub-Committee, will present the report.

Mr. E. T. Johnston (Erie):—The report of Sub-Committee 2—Produce Terminals, appears as Appendix B in Bulletin 340, pages 116 to 125 inclusive. It is submitted as information, and it is recommended that the subject be continued.

The President:—Is any discussion wanted on this?

Chairman H. L. Ripley:—This is merely a report of progress, and I move that it be so received.

The President:—Unless there is objection, it will be so ordered.

Chairman H. L. Ripley:—The next report, Appendix C, will be found on page 125, Provision for Parking and Garage Facilities for Private Automobiles of Railway Passengers at Passenger Terminals and Way Stations. Mr. E. J. Beugler, Chairman of the Sub-Committee, will make the report.

Mr. E. J. Beugler (Consulting Engineer):—This Sub-Committee was instructed about three years ago to look into the matter of the parking facilities and the garage facilities for passengers' automobiles at way stations and railway terminals. The Committee commenced its work by sending out questionnaires in order to determine just what the status, practice, and the problem was at the time.

The initial report of the Committee gave a summary of replies with respect to general practice as to provision of space or facilities, basis of charges, and whether the facilities provided stimulated railway passenger traffic or had a favorable influence on other railroad business. Information received indicated that parking was generally permitted at the owner's risk under certain restrictions and without charge; that some large terminal layouts provided special parking areas; and that convenient facilities were considered by some representative companies a favorable factor in holding or bringing back passenger traffic at way and terminal stations, particularly in commuting districts, and also a possible advantage to other railroad business. The answers, however, showed that a majority of railroads were giving only passive consideration to the matter.

In 1931 the report of the Committee was based on a supplementary questionnaire sent to certain roads, particularly those having situations entailing the parking problem. The replies indicated a more definite outline of general practice, some roads having a

fixed policy of service based on both direct and indirect advantages, and other roads making experiments under observation.

In view of the additional time required for the carriers to reach a definite conclusion, and particularly on account of the abnormal operating conditions, the Committee has, during the past year, given its attention to a review of the elements of design and adaptation of parking layouts. The development, as indicated in our report, depends primarily upon the area and shape of land or streets available. Numerous plans were received by the Committee which showed the subject was receiving careful consideration in new layouts or revision of old layouts. Fig. 1 and 2 in the report are based on characteristic plans received, supplemented by some experimental maneuvers with cars in various spaces and various situations. It is thought that the information shown on the exhibits in this year's report will assist somewhat in the design of layouts and securing economical use of available space.

In the space units shown in Fig. 1 for auto parking, the most economical for parking on both sides of the passageway seems to be afforded by a 90-degree angle, the least favorable arrangement being with a 30-degree angle. For parking on one side of the thoroughfare, 60 and 90 degrees are equally favorable, and 30 degrees the least.

The accomplishment of satisfactory layouts by cooperative arrangements as between municipalities, foreign public service companies and railroads, where each contributes to the improvements in one way or another, indicates the advantage of joint efforts.

This report is submitted as information only, and it has been recommended, in view of the present experimental nature of the matter, that the report be received as information and that the subject be held in abeyance for the ensuing year. I move that it be so accepted.

The President:—If there is no objection to that, it will be so ordered.

Chairman H. L. Ripley:—The next report of the Committee, Appendix D, page 129, has to do with Hump Yards and, in particular, retarder yards. Mr. R. J. Hammond, Chairman of the Sub-Committee, is absent and in his absence Mr. W. B. Rudd will make the report.

I may say that the Committee and the Association is very much indebted to three members of this Sub-Committee for the voluminous amount of work that has been done in connection with this report. Messrs. Rudd and Brown, representing the two signal companies, have given of their time and effort unsparingly, and Mr. Hand of our own railroad has worked with them. I want to thank them, and I think the three deserve your thanks for what they have produced here in the way of a report on a very complicated subject.

Mr. W. B. Rudd (Union Switch & Signal Company):—This is a little bit embarrassing after what the Chairman has just said.

You have just agreed to and adopted for inclusion in the Manual certain material on hump yards both with riders and retarders, which material is general principles. When the Engineer comes down to the job of actually solving a given problem, the principles are the first consideration, but he must know how to apply those principles.

This Manual material, as far as the work of the Committee was concerned, was completed a year ago when it was presented to the Association as information. The Sub-Committee this year has spent its efforts on a practical application of those principles. The studies have been on what might be called two different methods: one of calculation, and one of both calculation and graphs. Much valuable work was done on the graphical method, but the Committee did not feel that it had completed its

work on that method far enough to present a report this year. We are hoping we can do that next year.

The report, therefore, this year on pages 129 to 133 is a practical example of the application of the principles you have adopted for the Manual to a specific problem. The Committee feels that the method of application of these principles, that is included in this report, will be found of material assistance in studying the application of car retarders to either an existing yard or a new yard, even if there may be some slight variations to take care of local conditions.

I will not take your time to go over the report in detail. We believe it is self-explanatory, and it is the desire and recommendation of the Committee that the report be accepted as information and the subject continued. I would so move.

The President:—I feel the Association is very much indebted to the Rudd family, after the two reports we have had from them today.

Chairman H. L. Ripley:—Mr. President, you called attention to the thing I had in my own mind. I think it is unusual and perhaps unique for a father to make a report before the adjournment for luncheon, and have the son follow him with a report after luncheon. I am glad we have at least one member of the Rudd family on our Committee.

The report in connection with Coordination of Facilities at Rail and Water Terminals will be found on page 133. Mr. C. U. Smith is Chairman of that Sub-Committee. Is Mr. Smith here? Apparently not.

The Committee, through Mr. Smith, its Chairman, and largely through Prof. W. C. Sadler, one of the members of the Committee, collected a very great amount of information in connection with this problem of rail and water terminals, but since the assignment of this subject to this Committee a General Committee on Rivers and Harbors has been organized and made a standing Committee of this Association.

It seemed to our Committee that a good deal of the data that it was the original intent to develop by our own Committee properly belonged to the assignment that had been made to the Committee on Rivers and Harbors, and Mr. Smith, the Chairman of this Sub-Committee, being also a member of the Committee on Rivers and Harbors, was left to work the matter out between the two committees.

The report, as I may have stated, will be found on page 133 and, after due consideration, the General Committee made a definite recommendation that certain sections of the data be turned over to the Committee on Rivers and Harbors, with their agreement, I understand, and that other matters be considered and reported upon by this Sub-Committee next year. So the report of the Committee is one for the information of the Association only, and it has reached no conclusions.

The President:—It will be so received, if there is no objection.

Chairman H. L. Ripley:—The next report is found on page 134, Appendices F and G, and Mr. M. J. J. Harrison, Vice-Chairman of the General Committee, is Chairman of that Sub-Committee and will make the report.

Mr. M. J. J. Harrison (Pennsylvania):—As just indicated by the Chairman of the Committee, the report on the general subject of Scales occupies pages 134 to 140 inclusive in this Bulletin. It consists of two parts. The first, or Appendix F, covers specifications for railway track scale test weight cars. These specifications, as is indicated in the short introductory paragraph at the bottom of page 134, were developed in collaboration with the Committee on Car Construction of the Mechanical Division, A.R.A. and the National Scale Men's Association.

In the form in which the specifications are here presented, they have the approval of your Committee and also of the other organizations just named. This code of speci-

fications is here submitted as information, and it is recommended that it be so received, Mr. President.

The President:—If there are no objections, it will be so received.

Mr. M. J. J. Harrison:—Appendix G, beginning near the bottom of page 138 and continuing to the bottom of page 140, is a very short summary of a report of research work performed under the direction of Professor Wilbur M. Wilson, of the University of Illinois, a member of this Committee, in connection with the determination of the bearing value of pivots for scales.

That there may be no misunderstanding, attention is called to the fact that the matter appearing on page 140, headed "Conclusions," are the conclusions of the report of which this is a summary. A very large amount of valuable work has been done in making the investigation referred to. Your Committee was privileged to review the matter appearing in the report, and also to review the conclusions derived from that material, and it is a source of considerable satisfaction that, through the courtesy of the Director of the Engineering Experiment Station of the University of Illinois, we are privileged to present this short summary. It is presented here as information, and it is recommended that it be so received.

The President:—If there are no objections, it will be so received.

Chairman H. L. Ripley:—The last section of the report of this Committee will be found on page 141, Appendix H, and is a bibliography of railway stations, yards, marine terminals and rail-air transport, compiled by Mr. E. E. R. Tratman, the Chairman of that Sub-Committee. I will ask Mr. Tratman to explain his report and give us anything in addition that he may care to do.

Mr. E. E. R. Tratman (Engineering News-Record):—In preparing this bibliography on stations, yards and terminals for the past three years I have had in mind the great inconvenience due to lack of records of published material, as often experienced in my own work and probably by most Engineers and railway men at one time or another. Various people, including members of this Association, have asked me at times for prompt information or references on some particular subject or line of work, supposing such information would be at hand. It has often happened that very few references were available, and it has been necessary to spend considerable time in hunting through various volumes to get sufficient material for an adequate reply. There are many advantages and lines of usefulness in such condensed and comprehensive records on special subjects, and in preparing this particular bibliography for the Association it has been my aim to make it as complete and useful as possible.

The President:—I am sure all of us feel very much indebted to you, Mr. Tratman.

Chairman H. L. Ripley:—From my own personal experience, I question whether anything that this Association does is more helpful than a good bibliography properly arranged in connection with the various subjects covered by the reports, not only matters that have been presented to this Association, but matters in general.

I think we are indebted to Mr. Tratman for the very considerable amount of work he has done, not only this year but in previous years in connection with this matter.

That concludes the report of the Committee on Yards and Terminals.

It is our recommendation as to this bibliography that it be received as information and handled in the same way that previous reports of like nature have been handled.

The President:—As I understand it, that resolution covers the entire report of your Committee?

Chairman H. L. Ripley:—Yes, Mr. President. I move that the report of the Yards and Terminals Committee be accepted.

(The motion was regularly seconded, put to vote and carried.)

The President:—We think, Mr. Ripley, that the information you have given us is very timely and valuable, and your Committee is excused with our thanks (Applause).

Mr. W. J. Backes (Chief Engineer, Boston & Maine—by letter):—I have reviewed the report and feel that it is a very excellent one, particularly those portions covering Produce Terminals, Hump Yards, Parking and Garage Facilities for Private Automobiles of Railway Passengers at Passenger Terminals and Way Stations.

These are all very important subjects and any information which we can get on them is bound to be most helpful.

Mr. Geo. S. Fanning (Chief Engineer, Erie—by letter):—I have received from Mr. E. T. Johnston, Special Engineer in charge of Yard and Terminal Development, the following comments referring to the reports of the Special Committee on Clearances and the Committee on Yards and Terminals:

"You have probably noticed the conflict between the Special Committee on Clearances' Manual recommendation on page 110, Fig. 5, where a height of 3-ft. 3 inches is recommended for a close platform serving refrigerator cars, and the material in the Yards and Terminals Committee report, page 119, suggesting a height of 3-ft. 5 inches. I believe the former clearance entirely satisfactory for inspection platforms but not suitable for house platforms served by motor trucks as well as by cars. The percentage of refrigerator car doors which will foul a 3-ft. 5 inch platform is insignificant and therefore prefer the 3-ft. 5 inch height, particularly as a *clearance* dimension. Personally, I strongly favor the 4-ft. platform height where 8-ft. side clearance can be used."

I concur in what Mr. Johnston says. A copy of this letter is being sent to the Chairmen of the two committees.

Mr. E. H. Lee (President, Chicago & Western Indiana—by letter):—This report has been read with interest, and so far as I am able to judge it handles the various subjects covered well and thoroughly.

In view of the fact that the subjects covered are quite technical, I am inclined to feel that the members of the Committee as the result of their studies are in much better position to discuss these subjects intelligently than I could possibly be.

Mr. F. E. Morrow (Chief Engineer, Chicago & Western Indiana—by letter):—I have read this report with a great deal of interest and believe that it has been well prepared.

Mr. J. L. Haugh (Vice-President, Union Pacific System—by letter):—I have reviewed carefully the report of the Committee on Yards and Terminals published in Bulletin 340. Was really very much pleased with the completeness and ingenuity of the report.

The Committee is to be congratulated upon it. The report on produce terminals is particularly enlightening and the Committee has done well in its study on this important new phase of railroad terminals.

Mr. A. T. Hawk (Engineer of Buildings, Chicago, Rock Island & Pacific—by letter):—I have read this report carefully and have no suggestions or criticisms to make. I consider the report very complete as to detail and general information and very admirably written.

Mr. R. C. Barnard (General Agent and Superintendent, Pennsylvania—by letter):—These studies have, undoubtedly, been given a great deal of thought as the conclusions reached are practical and, except for local conditions, I believe, could be adopted generally with satisfaction.

I have no other comments, as the reports serve as an excellent guide in the consideration of the subjects covered.

Mr. Alonzo J. Hammond (Consulting Engineer, Chicago—by letter):—I offer the following discussion on the report of the Committee on Yards and Terminals: Appendix A, no comments except approval. Appendix B, I am pleased to note in the fourth paragraph the statement "from the standpoint of general economy, *union* terminals are favored, et. seq."

Even in Chicago I think this is quite desirable and the greater the concentration of freight switching movements, with local distribution by truck, the greater economies will prevail. This thought I would like to see carried through the entire freight terminal problem and hope the Committee can tackle this phase of it.

Appendix C, in view of the very common use of the private automobile meeting suburban trains, it would seem desirable to favor patrons with a proper consideration of

parking space and the current year seems a good time to give it consideration rather than to discontinue the subject.

Again it is becoming of increasing importance in metropolitan stations to have some space set aside for the private car meeting trains, and as space here is a serious matter, the subjects present an important economic problem worthy of serious thought, so that I would think a survey of the use of cars for this purpose should be made to determine the relative space needed and the increasing importance of the service.

It has recently come to my attention that a survey made of methods of parking indicated the preferable plan was parallel parking, more economical of space and better for the safety of the car. The schemes outlined on Fig. 1 would indicate the contrary for parallel parking, so it is possible the clearance for one way traffic is shown too great; why not a ten foot (10') traffic lane with two rows of cars, which would then make it more economical than at 90 per cent.

Appendix D, approval.

Appendix E, in view of the increased interest in water transportation this is an important subject.

My thought relative to the separation of the work of the Yards and Terminals Committee with that of the Committee on Rivers and Harbors would be to have all of the subject matter relating to transportation co-ordination in the hands of the first committee.

There is the economic problem of type of rail-river terminal for example which should have careful consideration. For example, the methods of transfer on the two sides of the Mississippi at St. Louis and East St. Louis, the latter, as I understand it, is the more economical plan and it is the economics of the problem I should like to see the Committee consider.

Appendix H, this is a valuable compilation and Mr. Tratman should be congratulated.

Mr. J. W. Foote (General Superintendent, Niagara Junction—by letter):—I am giving below my comments on report of Committee on Yards and Terminals, as contained in Bulletin 340:

Hump Yards—The report has been very carefully and thoroughly prepared and reflects great credit upon the Chairman and members of the Committee.

Appendix A—Would suggest that the words "roller-bearing cars" be inserted after the words "following wind", page 115 (a).

It may be well also to make tests of the running of roller bearing equipped cars as the use of such cars in greater numbers may require additional retarders in the main body of the yard.

No mention is made of the use of car skids in retarder operation. If the Committee is favorable to the use of such appliances, would suggest the words "and skids" be inserted after the word "retarders," page 115, fifth paragraph from bottom.

Appendix B—Produce Terminals—Would suggest mention being made under General or under Location, page 120 or 118, that driveways leading from city streets to produce terminal be of moderate gradient to permit easy access of heavily loaded trucks.

Appendix D—Hump Yards—As this subject is to be continued, the very important suggestion on page 129 that members submit plans and information of existing hump yards should, if not already done, be followed by questionnaires to all companies now operating retarder yards.

If such a questionnaire results in a composite summary of gradients and layouts, based upon operating experience, the report of the Committee, in which great progress has already been made, will be nearer inclusion in the Manual. The use of retarders has been so widely extended within the past few years that more complete check of the tentative formula will be possible.

I would suggest that typical vertical curves designed to avoid uncoupling and undue coupler strain be included in subsequent reports. Also that typical layouts to include scales and crossovers around humps be shown in future reports.

Mr. Frank R. Judd (Engineer of Buildings, Illinois Central System—by letter):—It seems to me that more prominence should be given the items "Auto Truck Scales" and "Pre-ripening Facilities" by including them in the list of facilities given on page 117 rather than casual mention of them in other parts of the report.

In the concluding paragraph of Appendix C, "Provision for parking, etc.," it would be well to include vertical parking machines on the same basis as the items of garage or repair facilities.

Other than this I have no comments except of a congratulatory nature. The information is very complete and excellently compiled.

Col. W. G. Arn (Assistant Engineer, Illinois Central—by letter):—The Committee has done a lot of excellent work and has a good report.

The only suggestions I have to make are minor ones and pertain to the wording. In Bulletin 340, page 114, there is given a sentence for insertion under the caption of "Freight Yards—General.". In the next to the last line of this sentence occur the words "without appreciable delay." It seems to me that this wording should be changed to "without undue delay", or "with minimum delay."

On page 118, paragraph on "Buildings"; last line of first paragraph reads: "Auction rooms require exceptionally good lighting, ventilation and accoustic treatment." It seems to me this might better be stated "Auction rooms should be designed to furnish proper lighting, ventilation and accoustics."

Mr. J.V. Dillabough (Transportation Engineer, Canadian National—by letter):—The following suggestions are submitted for the consideration of the Committee on Yards and Terminals, Sub-Committee on Scales; these remarks refer to Appendix F, page 134, Bulletin 340:

Classification—It is suggested that test weights be confined to fifty-pound units. One-hundred-pound weights are rather heavy to be handled around a test car by hand.

Primary Requirements—Suggested weights for a light car and a heavy car to be used in combination are 40,000 lb. and 80,000 lb.

Heavy cars of two axle construction and with the short wheel base (seven feet) suggested, would, it is believed, be liable to cause trouble in transit between points at which scales are to be tested, particularly on lines where scales are located long distances apart. It is suggested that cars on standard four wheel trucks with an appliance for raising one pair of wheels during test would give better all-round service.

Body Features—It is suggested that a clause be added to the effect that runways be raised high enough above the top of the car, say 4 inches, to allow accumulations of snow or ice to be easily and completely removed.

It is suggested that car movers be considered as part of the car weight for the reason that when making a test, the car movers could be left in position, if necessary, to hold the car at the point where the application of the load is desired.

Mr. W. P. Wiltsee (Chief Engineer, Norfolk & Western—by letter):—We have reviewed the report of the Committee on Yards and Terminals, and feel that the report is in excellent shape.

The subject of Retarder Yards has been gone into very fully and we note that a number of the features brought out in this report are in accordance with our knowledge of the subject, as developed in our construction of the Car Retarder Yard at Portsmouth, Ohio, and our Mr. Armstrong, who is a member of this Committee, no doubt rendered considerable assistance.

While we feel that the lapping of switches may, in cases where the lengths of tracks are limited, be advantageous, I am not of the opinion that a lap switch is the most desirable arrangement in a typical yard of this kind. It is of advantage to keep the switches spaced somewhat apart so that the tower man will have time to throw the switches between two cars, and also the cost of the maintenance of these lap switches is considerable.

Group track arrangement is an excellent idea and one that we, who have had experience with Retarder Yards, know is desirable. We notice the grades used on the yard tracks below the last retarders are only 0.22 of 1 per cent. We found by actual experiment in our East Portsmouth Yard that this grade was proper under temperature conditions of 70 degrees and over, to enable a car to continue rolling at four miles per hour, which is the proper coupling speed, but this grade would no doubt have to be increased where lighter cars predominated.

We consider that the report on Scales and Bearing Value of Pivots for Scales are very excellent reports and follow the experience of experts who have been investigating and designing scales in recent years, and we have nothing but favorable comment to make on this part, as well as other parts of the report.

Past-President J. L. Campbell (by letter):—This excellent report proposes nothing for the Manual, revision of the latter excepted.

I suggest that the wording of the first paragraph under Hump Yards, page 114, read as follows:

"When requirements justify a hump yard, the yard layout should so provide for continuous movement of a draft of cars over the hump that movement of the cars to their positions on classification tracks will be without damaging impacts and with minimum time between successive drafts." (See Vol. 30, page 762; Vol. 31, page 1014; and Vol. 32, page 693.)

Mr. E. R. Lewis (Principal Assistant Engineer, Michigan Central—by letter):—There is less I believe to criticize in this than in any A.R.E.A. report I have reviewed in recent years.

On the subject of Hump Yards, I believe this or some subsequent report should set forth for inclusion in the Manual a *paragraph on drainage* which should preferably be paragraph one, because this preparation for facilities is the first that should be considered on the site provided. Quick drainage of a hump yard is peculiarly necessary; subsurface and surface longitudinal and cross drainage. The cost varies from 2 to 8 per cent of the yard construction cost and especial attention must be given to draining tracks at point of change of track gradients. We have found the drainage problems worthy of study, whether humps are built in old yards or in new locations. It is desirable to provide a catchbasin for every turnout and retarder.

It probably will be found that freight classifications will vary largely in most hump yards from year to year with corresponding changes in yard operation. A word of caution on this point, as well as on height of hump, might not be out of place. It is much easier to raise hump tracks under traffic than to lower them. Special provisions of tracks in the receiving yard where cars may be cleaned and refuse disposed of are necessary. It is believed that temporary buildings, especially on the hump, are of ultimate economy in view of possible settlement of foundations and changes found desirable after the layout has been in operation for a term of months or years. Parking and garage spaces for employees' cars and for restaurant facilities tend to increase efficiency.

In the first paragraph of Appendix B, I would expand the first sentence to read "The object of produce terminals is to expedite, concentrate and segregate delivery *and if required* the *repacking* of perishable farm products, such as fruits, *melons,* vegetables." . . . While melons are fruits, this distinction is usual and melons constitute a considerable class of produce handled.

Under the caption "General Type", I would insert after 8, Offices, "restaurant space or building."

Under the caption "Buildings", I would alter the penultimate sentence to "Driveways between buildings or between a building and a team track should be *preferably* about 80 feet wide.

Under the caption "Track Layout", I would expand sentence one to read "The extent of the track layout depends on the number of cars to be handled at peak hours, *the different kinds of produce to be received,* and the average standing time until cars are received *and cleaned.*

Team Yard—Policing will do more to make possible the efficient use of team track driveways than widening. Truckmen will obstruct almost any width of drive unless under strict control. It must be railroad control because public authorities are not responsible for the use of driveways in yards.

Garbage and Refuse Disposal—Sentence 3—In larger layouts an incinerator *usually is* necessary. *The incinerator should be of ample capacity, centrally located* and designed to burn garbage having a high water content. *An incinerator requires expert attendance and careful operation.*

Sentence 4—Change "eight or ten" to "6 or 8" hours.

Under caption "General," page 120, I would emphasize sentence 3 as follows: The entire area *strongly and closely fenced,* etc.

Appendix C, Parking, etc.—We find that our parking facilities demand an attendance in control and use depot police for this duty. Without this control the privilege is abused by thieves, by careless parking and continuous use by irresponsible persons, instead of hourly occupancy.

I am not prepared to discuss the retarder yard plan insert, pages 132–133, but so many elements must be considered that full information on traffic and operating details must be known. The relations of retarder units and gradients seem reasonable. I do think that there should be more than one wider track spacing than 13 feet in a 44 track classification yard.

A rail and water terminal is by no means an unmixed blessing. Operating one is a good deal like playing billards on a pool table. One is continually getting into a pocket

somewhere, and it is always expensive. One of the greatest difficulties is that someone periodically has a bright idea that works out well in a letter but is impracticable.

The matters of scales and pivots has been so well presented that I would only add that moisture and corrosion are arch enemies of these important facilities. Mention thereof may be considered out of place in this report, but should have some place in the Manual or Proceedings.

DISCUSSION ON SHOPS AND LOCOMOTIVE TERMINALS

(For Report, see pp. 439–473)

Mr. L. P. Kimball (Baltimore & Ohio):—The report of the Shops and Locomotive Terminals Committee will be found in Bulletin 343, beginning on page 439. The first subject is found in Appendix A on page 440, Revision of Manual. Report on this subject will be presented by Mr. F. E. Morrow, Chairman of that Sub-Committee.

Mr. F. E. Morrow (Chicago & Western Indiana and Belt):—Some of the changes recommended are to bring the recommended practice of engine house design and store houses for shops and locomotive terminals in line with changed practice and others to harmonize them with subsequent recommendations on allied subjects and to clarify expression.

The first change is under engine house design, turntables, and is an addition, to cover three-point turntables. As proposed, it reads as follows:

"If balanced type turntable is used, it should be long enough to balance the engine when tender is empty. Use of a three-point table removes this necessity and is preferable, where long engines are to be handled."

The second change is under smoke jacks and consists principally of change in language and certain additions to harmonize them with the recommendations under ventilation of engine houses. The revised recommendation reads as follows:

"Smoke jacks should be of the fixed type, the bottom opening not less than 42 inches wide and long enough (preferably not less than 12 feet) to receive smoke from the locomotive stack at its limiting positions, due to the shifting of locomotive, so as to bring driving wheels and side rods into proper position for repair and also to avoid unnecessarily close spotting of locomotive. The bottom of the jack should be as low as the locomotives to be handled in the house will allow, usually 16 feet 6 inches at ends and 15 feet 6 inches at sides above top of rail, and it should be furnished with a drip trough. The slope upward to the flue should be uniform. The cross-section area of the flue should be not less than seven square feet. An annular space two inches in width should be provided around the flue for engine house ventilation. Jacks should be constructed of non-combustible materials.

"When the engine house is without a turntable, smoke jacks should be located at each end of each engine space. Smoke jacks are unnecessary in an engine house where direct steaming is used, but for special conditions it may be found desirable to install them over a few stalls to permit housing of live locomotives when necessary. In some locations, due to local conditions, special types of jacks are installed in connection with smoke abatement measures."

The third change is under engine pits and consists of reducing the recommended minimum width from 4 feet to 3 feet 9 inches, increasing the thickness of side walls from 2 feet 7 inches to 3 feet, with a provision for drainage at both ends of pit for long pits. The recommendation as revised reads as follows:

"Engine pits should extend from a point 10 feet from the inner circle columns to a point 13 feet from the inner face of the outer circle wall. They should have a clear width of not less than 3 feet 9 inches, and a minimum depth below base of rail of 2 feet 6 inches, increasing with the slope of the floor of the pit to at least 3 feet. The floor of the pit should be convex and top of walls should be of such width as to provide proper jacking space, usually about 3 feet. Where direct heating is used, the pit

walls may be recessed for radiation. For long pits, drainage may be provided at both ends of pit with high point in middle."

The fourth change is under windows and consists of the addition in reference to pivoted sash which is already recommended practice under ventilation of engine houses. As changed it reads:

"The disadvantages of skylights are so much greater than their advantages as to make them undesirable.

"Windows in the outer walls should be made as large as practicable with the largest glass or light area consistent with the strength of the structure. These windows should be provided, as far as practicable, with a continuous row of pivoted sash along the top of windows. In general, the lower sill should be not more than 4 feet from the floor, and space between window frames and columns or pilasters and girders only that necessary to secure the window frames.

"When doors are provided, they should be glazed with glass panels with wire glass."

The fifth change is under mechanical handling devices, and as revised is as follows:

"The common use of electrically propelled and operated industrial tractors, trucks and portable cranes practically eliminates the need of traveling cranes, pit cranes or mono-rails, except, perhaps, in a limited portion of the engine house where considerable shop work is done."

The sixth change is under floors and consists of adding asphalt blocks. As changed, it reads:

"The floors should be of permanent construction sloped so as to drain properly. The floor around the outer circle and for the outer bay or outer two bays where trucking is carried on and most of the work is done, may advantageously be constructed of wood blocks, asphalt blocks, or vitrified brick on a concrete base, while the remainder of the floor between pits may for the sake of economy be of concrete."

Under Store Houses for Shops and Locomotive Terminals, the first change refers to floor elevation under arrangement. As changed it reads as follows:

"The primary consideration is the economical handling of material. The arrangement should be such as to insure ample natural light, and convenient handling, checking and inventorying of materials, and ease of supervision. The store house floor should be at car floor level. Where not enough store supplies are received or shipped from the store house to justify the construction of the store house floor at car floor level, the cost of construction may be reduced by constructing it at practically the track or ground level with raised platform and ramp for unloading to and from cars. Racks should be so located that the handling of materials will be reduced to a minimum, and so that there will be no dark pockets for the accumulation of rubbish, etc. Main aisles of ample width should be provided to allow for the handling of material by motor truck."

The second change refers to the construction of casting platforms, and reads:

"Platforms should be supported directly on the ground, and if the floor level be elevated it should be on fill between retaining walls."

The third change is under the construction of oil houses, and is for the purpose of clarifying the language, and as changed reads as follows:

"Oil houses should be constructed of fire resistive materials, including steelsash with wire glass, and all doors in partition walls strictly fire doors controlled by fusible links."

I move that these recommendations be accepted for inclusion in the Manual.

The President:—Gentlemen, you have heard the motion. Is there any discussion?

(The motion was put to vote and carried.)

Chairman L. P. Kimball:—The next report of the Committee is found in Appendix B, beginning at the lower part of page 441. This report has to do with the design of loco-

motive repair shops and is a continuation of the subject previously reported on by the Committee in the 1929 Proceedings, pages 361 to 378.

The Committee feels now, as it felt at that time, that it is not justified in laying down any fixed rules as to the type or size of shop to be recommended as established practice. There are, however, certain fundamentals involved in the design of a locomotive repair shop which are basic, irrespective of the type selected.

The purpose of this report is to assist those members who may be confronted with the necessity of designing a locomotive repair shop, in proportioning the space allotted to the various departments. The basis of the report is a time study for just such an operation which was prepared and used by the Chesapeake & Ohio Railway in their locomotive repair shop at Huntington. The Committee has attempted to present that data in such shape as to be usable in connection with similar problems, and it is recommended that the report be accepted as information.

The President:—Gentlemen, this certainly has a lot of very useful and pertinent information, and unless the Chair hears an objection, I am sure we will be pleased to accept it as such.

Chairman L. P. Kimball:—The next report appears in Appendix C on page 460. I neglected to say in connection with the previous report that Mr. Harris, who handled that subject as Sub-Committee Chairman, was unfortunately unable to appear here today. The same thing applies to the next two reports, Subjects (3) and (4), Appendices C and D, in the case of Mr. Dougherty who is Chairman of those Sub-Committees.

Subject (3), Appendix C, is entitled, "Adapting the General Layouts and Design of Car Shops for Inspecting and Repairing Multiple Unit Electric Cars." In studying this subject, the Committee found that, with one exception, the railroads using multiple unit electric cars had installed new shop facilities for this purpose rather than adapting existing terminals or buildings for the purpose. While an ordinary passenger car shop is well adapted for the handling of multiple unit cars, with slight changes and additions, the roads having the problem have generally found the locations were unsuitable and, with the one exception above mentioned, have constructed entirely new facilities for the purpose. The report is submitted as information.

The President:—Is there any objection or any comments, gentlemen? It is so accepted.

Chairman L. P. Kimball:—The same conditions largely apply to the report on Subject (4), Appendix D, beginning on page 461. This subject is allied with the previous one and is entitled, "Adapting the Design of Engine Houses and General Layouts and Design of Typical Locomotive Repair Shops for the Inspection and Repair of Electric Locomotives." That is, electric locomotives as distinguished from multiple unit cars.

In this case, also, the Committee, as a result of a questionnaire requesting information from railroads having electric locomotives in service, found a record of only one case in which an existing engine terminal had been adapted to the handling of electric locomotives. The layout of this particular installation and some descriptive data in regard to same is included in the report. Generally speaking, however, the question of location has seemed to govern as in the case of the multiple unit cars, and the roads have apparently been reluctant to use the existing facilities, particularly as in most cases where they were designed for steam locomotives they consist of a circular engine house served by a turntable. The use of a turntable, of course, in connection with most electric locomotives is unnecessary as they are equipped for operation at both ends, and up to the present time, at least, the adaptation of the steam facilities has been little used. The report, however, is submitted as information.

The President:—Are there any comments or suggestions or questions you would like to ask? It is so received, Mr. Chairman.

Chairman L. P. Kimball:—The next subject (6), appears in Appendix E, beginning on page 464. It is again unfortunate that Mr. A. T. Hawk, former Chairman of this Committee, who was assigned as Chairman of the Sub-Committee, was sent out of town unexpectedly yesterday and is unable to present his report. This subject is entitled "Modernization of Engine Terminals to Eliminate Use of Steam Power Plants for other than Heating Purposes."

It was found that many roads have considered it desirable and economical to rearrange their engine terminal facilities so as to permit the discontinuance of the use of the steam boiler plant during the season when heat is not required. This report discusses the various items that are necessary for consideration in connection with such a program, and the information contained in same is presented for the information of the Association.

The President:—Unless I hear comments to the contrary, it will be so received.

Chairman L. P. Kimball:—The next Subject (8), Design of Inspection Pit, is found in Appendix F, beginning at the top of page 467. This subject will be presented by Mr. H. C. Lorenz, Chairman of the Sub-Committee.

Mr. H. C. Lorenz (Cleveland, Cincinnati, Chicago & St. Louis):—Last year this Committee made a report on inspection pits which was presented to this Association as information. The Committee on Outline of Work saw fit to reassign to this Committee the subject Design of Inspection Pit, which appears on page 467. It is presented to you for your approval and insertion in the Manual.

Before reading the report, I would like to make the following remarks: The Committee has confined its report to outside locomotive inspection pits used in connection with engine houses only, and not to inspection pits located at some station for the purpose of inspecting engines on through runs or those used in connection with repair shops. The Committee also thought it necessary not to make recommendations too rigid, since practice as to location, communication with the engine house, means of access, and other features, vary to a great extent.

Questionnaires sent to 25 railroads developed that only nine used them. One of the largest railroads operating in the Middle West and East has installed them at several large terminals but has since decided their use does not fit in with their present practice, as changed methods of locomotive maintenance, that is, the monthly pick-up at the time of federal certificate inspections are made, assignment of locomotives by definite engine houses for home maintenance, and the better maintenance of locomotives, have eliminated, in their experience, any necessity for outside inspection pits, with the exception of one location, at which engine house is too small and inspection pit is used as an adjunct thereto.

The following report on the design of inspection pits is presented to you for approval and insertion in the Manual:

"Locomotive inspection pits are for the purpose of inspecting locomotives, as follows:

"(1) Before entering engine house, to save dispatchment time. (In a terminal turning 40 locomotives per day, it has been estimated that a saving of seven and one-half minutes per locomotive may be effected.)

"(2) In cases of engines running through a terminal or switch engines working on a 24-hour shift. (All the engine house work is done while engine stands on inspection pit.)

"(3) Where engine house facilities are not modern or are too small for the power. (Other conditions may obtain to warrant installation, but on account of varied requirements and practices on different railroads, the use of inspection pits is not general.)

"Inspection pits are usually located either between turntable and washing platform, or just beyond coaling or fuel station, i. e., on the side farthest from turntable.

"Recommendations. Inspection pits should be 3 to 4 feet deep, measured from base of rail, or a length not less than the longest locomotive to be inspected, and provided with ample drainage.

"Convenient access should be provided by stairway. (In some instances, direct access has been provided from inspector's office by tunnel)

"Fixtures should be provided for general lighting and service outlets for extension cord, for detail inspection.

"A telephone should be provided for communication with engine house, and may be supplemented by the installation of a pneumatic tube system for sending reports to the engine house."

Mr. C. C. Cook (Baltimore & Ohio):—May I ask you if it is simply the intention to place the recommendations in the Manual, or the entire report.

Mr. H. C. Lorenz:—The entire report as it appears on page 467.

The President:—Are there any comments, gentlemen, or questions you would like to ask?

(The motion was put to vote and carried.)

Chairman L. P. Kimball:—The next Subject (9), Engine Terminal Layouts, appears in Appendix G beginning at the lower part of page 467. This subject will be presented by Mr. J. M. Metcalf, Vice-Chairman of the Committee, and Chairman of this particular Sub-Committee.

Mr. J. M. Metcalf (Missouri–Kansas–Texas Lines):—The Committee has continued the study of engine terminal layouts which was previously reported on in 1922 and 1926, and submits the report found on pages 467 to 473, Bulletin 343.

The Committee has tried to set up for the Manual a somewhat more extensive statement of the general principles of design which we believe may be of assistance as a guide to those working on such problems. We recommend that these conclusions, 1 to 24, as printed on pages 468 to 471, be adopted for the Manual.

The President:—Do you mean the full report?

Mr. J. M. Metcalf:—I mean the conclusions only.

The President:—You probably should read the headings and pause to give the members time to comment.

Mr. J. M. Metcalf:—Under the heading of Site we have one conclusion, No. 5 on page 469. Track Layout, conclusions 6 to 11, on page 469. Water Facilities, conclusions 12 and 13, on page 470. Office and Service Buildings, conclusions 14, 15 and 16. Lighting, No. 17. Telephones, No. 18. Fire Protection, Nos. 19 to 23. Other Facilities, No. 24, which includes the reference to other conclusions in the Manual related to engine terminal layouts.

The President:—You have heard Mr. Metcalf's report, and the recommendation that this be included in the Manual. Are there any comments or questions, or any discussion?

(The motion was put to vote and carried.)

Chairman L. P. Kimball:—That concludes the report of this Committee.

The President:—Mr. Kimball, we think you have given us a lot of practical, useful information. We would like to compliment the Committee on their good work, and with that you are excused (Applause).

DISCUSSION ON STANDARDIZATION

(For Report, see pp. 149–160)

Mr. J. C. Irwin (Boston & Albany):—The report of this Committee is the first one in Bulletin 341, page 149.

The chief functions of this Committee are to encourage the use of the A.R.E.A. recommended practices and to consider subjects to be presented to the Board of Direction for sponsoring as national standards; also to maintain contact with standardization bodies and give this Association information that may be of value in connection with those contacts.

We recognize the fact that the recommended practices of the A.R.E.A. as published in the Manual are not fixed standards. They are what they are said to be, recommended practices, useful for reference, and we feel very often that we do not give full consideration to the possibility of using them as they are presented. I believe in many cases the practices can be used as they are presented in the Manual, where very often personal equation is injected which, to some extent, destroys the work which has been done in this Association.

In order to emphasize a few salient features, I will present the beginning of the report.

"In previous reports of this Committee it has been pointed out that the primary influence of this Association toward the economies and conveniences of Standardization will be through the interest of its members in the use of the recommended practices in the Manual. The endorsement and approval by the American Railway Association is of special significance as indicating recognition of the value of the expert skill and judgment by which the Manual has been developed and the importance of securing the greatest benefit from it by the application of its principles to work leading to Simplified Practice and Standardization.

"Men trained in the work of this Association are collaborating with those from other Sections and Divisions of the American Railway Association together with men assigned by associations of all sorts of united industries and by Departments of the National Government in the creation of 'American Standards' through the fundamental work in the sectional committees of the American Standards Association, thus carrying the influence of the A.R.E.A. into the entire field having common interests in the projects under study."

This Association is an important part of the machinery of the American Standards Association because when a project is presented in which railways might be interested, the American Railway Association, Engineering Division, is asked to appoint a representative to join in with others in doing the work in a sectional committee which really creates the standard to be presented to the Council of the American Standards Association for consideration as to the adequacy of the study and the completeness of representation in order to decide whether that is a suitable subject properly studied and ready for national standardization. So our members should realize that they are already a part of a piece of machinery which is creating national standards.

A standard can remain a standard only so long as it represents the best practice in the light of present knowledge. However (and this is a point which I wish to emphasize), in order to maintain the value of standards, revisions should be made by the same agencies that create them. Otherwise there will be a return to the original chaotic conditions which brought about the creation of the standard. That is one of our dangers at the present time. By simply referring to recommended practices and then going off and creating something quite different but in which we think we have given the recommended practice full value, we are getting throughout the country a lot of divergence in

practices which I think can be made more uniform by better attention to the work of this Association.

"The Committees of the A.R.E.A. are charged with the responsibility of keeping its Recommended Practices up to date. In order to do so intelligently, their members must keep informed on progress in the state of the art in any direction affecting the subject under study. It is especially important that men assigned to sectional committees of the American Standards Association be members of the Committees of the A.R.E.A. having similar subjects under their charge so that there will be perfect collaboration between the two Committees. This can be secured only by each Committee being completely informed on the activities of the other and by agreement on various matters as work progresses, before views become so divergent that they cannot be brought together."

The point here is that in appointing men to the sectional committees which are studying projects for the American Standards Association for the creation of national standards, we must give due credit to the work they are doing, and if we have Committees of the A.R.E.A. working on the same subject they must work along together. Otherwise we are creating two different standards, the one of the American Standards Association which is recognized as a national standard, and one which comes out as the recommended practice of this Association.

In order to give this Association the closest possible ties with the national standardization bodies, we began last spring by arranging a meeting with the Bureau of Standards in Washington, recognizing the fact that the government agencies are doing very important work in the way of creating standard specifications, and standards for material, and we wish them to know what we are doing in the same line and have them give due credit and take cognizance of it, at the same time enabling the various chairmen of committees who are members of this Committee, to realize better what the government is doing and the ways in which we can help to cooperate in national standardization.

A meeting was held last May with the Bureau of Standards, and besides being welcomed by Dr. Burgess, the Director, our Committee was addressed by five representatives of the various divisions of the National Bureau of Standards.

During this coming spring we shall have a meeting with the American Standards Association in somewhat the same way so that the staff of that association can talk to the members of this Committee, and our members can explain to them the nature of the work we are doing. In this way we are continually helping to secure cooperation in the creation of national standards which we may use.

One of the most important features of the work of standardization is simplified practice. There is no use of standardizing a lot of things if we can get along with in fewer number, and the first thing is to see to what extent we can reduce stock or reduce our requirements by the elimination of unnecessary or uneconomical types or sizes, or grades of material that will enable us to use larger quantities of the few remaining types left, and by standardizing those to get the greatest benefit of the work of simplification and standardization.

"The Division of Simplified Practice of the National Bureau of Standards, U.S. Department of Commerce, is maintained for the purpose of fostering this work. Its function is to bring together all parties interested in a project of this character and to aid in coordinating their work in developing a simplified practice recommendation. Its services are available for the study of any project."

The Division of Simplified Practice is in an especially good position to call together all the industries in the field of a certain kind, all the manufacturers, and enable them to agree to reduced numbers of sizes, designs, and grades and get stock down to a reasonable number.

The Division of Simplified Practice issues bulletins from time to time stating what they have accomplished in the way of reducing the number of types and sizes of various

kinds of materials. It is obvious that the greater the simplification, the greater the economies for all concerned.

The American Railway Association is represented on the Board of Directors of the American Standards Association by Mr. L. A. Downs, our former President, and President of the Illinois Central, and it has representatives also from the Engineering Division, the Operating Division and the Mechanical Division on the Standards Council of the American Standards Association. Before any projects are adopted as standard, they are submitted to this Standards Council for vote, yes or no, after considering the adequacy of the study and the recommendation of the sectional committee. Therefore, this Association is taking an important part in this work.

There are two projects which have been before the American Standards Association for eight years which it was necessary to withdraw during the year; these concerning the work of our Committee on Iron and Steel Structures. One was for specifications for steel railway bridges, and the other was for specifications for movable railway bridges. Various committees were appointed, and the studies went through a series of years, but probably on account of the change in the state of the art or on account of the difficulty of dealing with some consulting engineers, whatever may have been the cause, "After due consideration, the Committee on Iron and Steel Structures unanimously concluded 'that these specifications are not adapted to the requirements of the A.R.E.A. for the design and construction of steel railway bridges, and recommends that no action be taken toward having these or any other specifications for steel railway bridges adopted as American Standard'." "These specifications" in that case refers to a specification which is the result of the joint work of the Committee of the American Society of Civil Engineers and the American Railway Engineering Association. If further information is desired on that point, Mr. A. R. Wilson is in the best position to give it.

This Committee at the present time is considering some new subjects with the possibility of national standardization, and their function will be to recommend them to our Board of Direction for sponsoring in the American Standards Association as such subjects are found suitable.

During the year, in the American Standards Association, the work along electrical lines was concentrated in what is known as the Electrical Standards Committee. This Committee functions as an integral part of the American Standards Association, and it was created "to provide a single central standardizing committee within the field of the electrical industry both in the United States and in contact with international standardization for the development of American Standards for the electrical industry under the authority of organizations duly represented in E.S.C. and of the American Standards Association, subject to the Constitution, By-laws and Procedure of the American Standards Association." In that Committee, the American Railway Association is represented by Mr. Sidney Withington.

The Canadian Standards Association is maintained practically for the same purpose as the American Standards Association, although with not such a large personnel, but on its Main Committee the American Railway Engineering Association is represented by five members: Messrs. Bond, Fairbairn, Monsarrat, Simmons and Stewart, so that in this work we are tied up and kept informed in regard to what is being done in Canada.

As a result of our Committee meeting in Washington, this Committee asked Mr. Edwin C. Ely, Chief of the Division of Simplified Practice, to prepare a concise paper on the possibility of the simplification of standards in the railway field. You will find this published on pages 154 to 156.

Keeping this Association informed as to what has occurred during the year, I will direct you to page 157 where there is listed the standards approved by the American

Standards Association in the period from September 1, 1930, to September 1, 1931. There are quite a number of projects here which you will recognize as being of value to railways, and altogether there are 45.

On the following three pages, which are the last pages of the report, you will find the list of men designated by the American Railway Engineering Association or by other Divisions of the American Railway Association to serve as representatives on the Sectional Committees which are studying the various projects for standardization. These are divided by the various groups, the Engineering Division corresponding to the American Railway Engineering Association, coming first. Altogether at the present time there are 49 such projects under study.

This report is informative and carries no recommendations on which you are asked to act, but we are ready to give any information.

This completes the report of the Committee.

The President:—I wonder if there are any questions any of the membership would like to ask Mr. Irwin in connection with this report. If there are no comments, the report will be received.

Your Committee is to be congratulated for its splendid work and report. Thank you, Mr. Irwin (Applause).

DISCUSSION ON MAINTENANCE OF WAY WORK EQUIPMENT

(For Report, see pp. 149–160)

Mr. C. R. Knowles (Illinois Central):—The report of the Special Committee on Maintenance of Way Work Equipment appears on page 161 of Bulletin 341.

The first report on Standardization of Parts and Accessories for Railway Maintenance Motor Cars appears on page 162, Bulletin 341, under Appendix A.

This subject has been before the Association for several years, and from time to time different items pertaining to the construction of maintenance of way motor cars have been recommended as simplified practice. This year we are offering as recommended practice frame bolts and gasoline fuel lines for section duty motor cars. These specifications are recommended for inclusion in the Manual. I will read them.

"1. Frame bolts for Section Duty Motor Cars shall be ¼ inch, ⅜ inch, ½ inch and ⅝ inch in diameter and shall have U.S. standard cut threads. Carriage bolts in wood frames shall be equipped with head locks and lock nuts; machine bolts in steel frames shall be equipped with lock washers.

"2. Gasoline lines shall be annealed copper tubing of not less than No. 19 B.W. gage in thickness, having ¼ inch outside diameter. Gasoline line connections shall be of packing type (see Fig. 1) with ⅛ inch pipe thread on one end and ½ inch S.A.E. standard No. 20 thread on the other end.

"3. Cars shall be equipped with rail skids, the bottom of skid being not more than 3 inches above top of rail, skid being not more than ½ inch from back of wheel flange.

"4. Extension lifting handles shall be provided at purchaser's option. If used, extension lifting handles should be of 1¼ inch pipe, preferably double strength, and provide 30-inch extension.

"5. Windshields shall be of a type adaptable to the standard safety rails and shall be detachable. At purchaser's option, they shall have one or two windows of shatterproof glass or of viscoloid, or may be of baffle type."

I move that these specifications be adopted for printing in the Manual.

The President:—You have a motion before you, gentlemen. Is there any discussion on it?

Mr. W. C. Swartout (Missouri Pacific):—It occurs to me that in Item No. 2, instead of simply saying "S.A.E. standard No. 20 thread," you should say what that stand-

ard thread is, for the reason that S.A.E. standards are not generally available for our membership.

Chairman C. R. Knowles:—This dimension is given on page 164. S.A.E. standard thread is the only thread available on this type of coupling.

Mr. W. C. Swartout:—That is true, but the drawing on page 164 does not indicate what an S.A.E. standard thread is.

Chairman C. R. Knowles:—It is the same thing as U.S. standard thread, it has the same significance.

Mr. W. C. Swartout:—My objection is not that it has not the same significance, but S.A.E. standards, while available to members of the Society of Automotive Engineers, are not available to our membership.

Chairman C. R. Knowles:—Is it the speaker's thought that these couplings should be manufactured by the railroads?

Mr. W. C. Swartout:—Oh, no. You should furnish a drawing showing what the S.A.E. standard is in our publications for the reason mentioned.

Chairman C. R. Knowles:—I would like to ask, in what detail is the drawing deficient?

Mr. W. C. Swartout:—Well, what is the S.A.E. No. 20 thread?

Chairman C. R. Knowles:—In other words, the only thing lacking is the number of threads to the inch?

Mr. W. C. Swartout:—No; I do not know what an S.A.E. standard thread is. I know what the U.S. standard is, but I do not know what the S.A.E. standard is nor can it be readily ascertained.

Chairman C. R. Knowles:—On the other end of the same coupling is shown a standard pipe thread. Do you mean that the Committee should explain what a standard pipe thread is?

Mr. W. C. Swartout:—I am not talking about the pipe thread. I am talking about the other one.

Chairman C. R. Knowles:—It is six of one and half a dozen of the other, as I see it. Will the speaker outline just what he means? The plan shows the complete assembly, which is a standard connection and available in any automobile supply house or from any manufacturer of brass goods.

Mr. R. P. Winton (Norfolk & Western):—I think you will find there is a National thread which has been approved by the A.S.A. which takes the place of the S.A.E. thread, and therefore this specification should refer to the National Standard thread, the dimensions, angle, thread and tolerances of which are specified in the A.S.A. specification. Therefore, it should be substituted for the S.A.E. thread.

The President:—Will the Committee accept that suggestion, Mr. Knowles?

Chairman C. R. Knowles:—I am not sure that we would, Mr. President. This coupling was adopted after taking into consideration various couplings now in use and is identical with the majority of pipe couplings now in use on motor cars.

The President:—Is there any other discussion on this?

Mr. R. P. Winton:—I move that the question of the thread be referred back to the Committee for further study before the approval of the standard.

The President:—You have heard the motion. Is there any further discussion on the subject? If not, the question is before you.

(The motion was put to vote and carried.)

Mr. E .A. Hadley (Missouri Pacific):—I should like to know which motion we were voting on. If I remember correctly, there was one motion made and seconded that the

recommendations made be approved, and another referring it back to the Committee to study the question of the thread.

The President:—We were voting on Mr. Winton's motion at that time. If there was a general misunderstanding about that, we might put the question again.

Is the question that is in doubt clear now?

(The motion was put to vote a second time and carried.)

Chairman C. R. Knowles:—The Committee considers itself properly chastised.

The President:—I understand now, gentlemen, that the remainder of these five recommendations to go in the Manual are before you.

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—The balance of the report is presented as information.

The next report on Adaptability of Air and Electric Driven Tools in Railway and Maintenance of Way Work appears in Appendix B on page 168.

This report discusses the adaptability of air in electric tools, both used as individual units as in connection with other power units, such as pile drivers, and so forth.

Application of a list of operations is given on page 169, in which suggested applications of compressed air are given, and on the same page at the bottom, the application of electricity in the operation of tools.

On page 170 is a table showing the extent of use of pneumatic and electric tools on various railroads and closes with a general discussion of the adaptability of these tools, with the conclusion that compressed air and electric tools have proved economical and efficient in many railroad operations, and that there are possibilities for further development, with the recommendation that the subject be continued.

The President:—If there is no objection to that, it will be continued.

Chairman C. R. Knowles:—The next report, Use and Adaptability of Dragline Equipment with Caterpillar Traction in Maintenance of Way Work, will be found under Appendix C, page 172 of Bulletin 341.

The report is based upon information furnished by railroads using this type of equipment and gives a general description of the methods employed in using the machines, together with a description of the various classes of work in which they have been used, and the general results obtained both as regards the character of work and cost. Only sufficient cost data has been given to make the report comprehensive.

The report is submitted as information with the recommendation that it be accepted as such, and the subject discontinued.

The President:—Is there any discussion on that conclusion? Do I understand, Mr. Knowles, that it is the wish of your Committee that this subject be discontinued as part of the assignment?

Chairman C. R. Knowles:—Yes, sir. A similar subject is being undertaken this year under the general heading of application of track type tractors to railway work.

The President:—I would like to know if that is the wish of the Association.

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—The next report, the Use and Maintenance of Paint Spraying Equipment with Outline of Typical Organizations for Various Classes of Work, appears under Appendix D on page 176 of Bulletin 341.

This report gives a brief résumé of the development of paint spraying equipment, discussing the earlier type of paint spraying machines as compared with the modern machines of various types, and gives a classification of the various types of machines according to the method of feeding paint to the gun.

It also discusses briefly the source of power, the mounting of the unit on skids, wheels, etc., and lists briefly a part of the uses to which the machine may be put.

It also includes organization for paint spraying including camp car outfits as well as personnel. The conclusions reached by the Committee were:

"In view of the fact that the use of paint spraying equipment is developing so rapidly on American railroads, it is considered inadvisable to make any definite recommendations regarding its use or the organization of paint forces at the present time."

This report is also offered as information with the recommendation that the subject be discontinued.

The President:—Do I hear any objection to that disposition of the subject? If there are no objections, the discontinuance will be ordered.

Chairman C. R. Knowles:—The next report, Organization for the Use and Maintenance of Ballast Cleaning Machines and Conditions Under which Each Particular Type May be Used, appears under Appendix E, page 183 of Bulletin 341. This report will be presented by Mr. William Elmer, who is Chairman of the Sub-Committee.

Mr. William Elmer (Pennsylvania):—The report of this Sub-Committee is found as stated by Mr. Knowles.

Cleaning of ballast is an old subject, and the ballast fork is one of our oldest tools. So long as it was possible to raise track, it was not found necessary to do much deep cleaning, but in recent years in the more densely populated parts of the country where numerous permanent platforms have been built and many overhead bridges are found, it is no longer possible to raise track.

During the World War, on account of the shortage of labor and the high wages paid in the maintenance of way department, it was necessary to develop power methods of cleaning ballast.

The use of the modern heavy locomotives, with firing rates of upwards of 10,000 lb. of coal per hour, from 10 to 20 per cent of which is discharged from the stack due to the use of self-cleaning front ends, there is now showered down on the roadway in dense traffic territory enormous quantities of sparks and cinders. These work their way down into the interstices between the stones of rock ballasted track and clog the drainage, resulting in pumping ties and rough track.

A number of machines for cleaning stone ballast have been devised, among which may be mentioned ditchers and jib cranes operating clam-shell buckets, whereby the dirty ballast is lifted from the intertrack space and poured over screens, the dirt passing through and the cleaned stone rolling back to the track.

The mole is a machine which works in the intertrack space or on the shoulder and does not occupy or obstruct a track.

More recent machines of high capacity have been developed, and these have brought the cost down to about 6 cents per linear foot of intertrack space, or 3 cents per foot of shoulder cleaning. They have a capacity of more than 50 miles of intertrack space cleaned per month, and will go 18 inches below the bottom of the ties if the ballast is that deep. It is not uncommon to get 500 tons of dirt in a day's work.

Chairman C. R. Knowles:—This report is submitted as information with the recommendation that the subject be discontinued.

Mr. V. R. Walling (Chicago & Western Indiana):—I am wondering if this Association is being altogether consistent in the handling of the items in what appears to me to be a very important Committee. The Committee start out by recommending for inclusion in the Manual standardization of certain parts and accessories for railway maintenance motor cars. Then they take up four very important subjects, it seems to me, such as the adaptability of air and electric driven tools in railway maintenance of way work, the use and adaptability of dragline equipment with caterpillar traction in maintenance of way work; the use and maintenance of paint spraying equipment with

outline of typical organizations for various classes of work; organization for the use and maintenance of ballast cleaning machines, and so forth; also, the use of oil spraying machines for oiling rails and fastenings, and it is proposed to discontinue all of these subjects.

It seems to me it might be wise to continue these subjects, because it is a question whether the field has been entirely covered and because of continued improvements in these various machines. It would seem well to keep these matters alive because in my opinion they are of vital importance to the railroads, particularly at this time.

Mr. J. V. Neubert (New York Central):—I would recommend that the subjects of spray painting and ballast cleaning be referred back to the Committee on Outline of Work for consideration.

The President:—Is there any discussion on Mr. Neubert's motion?

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—We will be very glad to give the subjects further consideration.

The next report, the Use of Oil Spraying Machines for Oiling Rails and Fastenings, Steel Structures and Roadbed, appears under Appendix F, page 190, Bulletin 341.

This report, as the title would indicate, deals with the use of oil spraying machines for oiling rails and fastenings, and discusses the causes of rust, such as moisture, drippings from locomotives, locomotive gases, refrigerator brine drippings, etc. This is followed by a discussion of rust prevention by oil application and roadbed oiling. Also attached, as part of the report on page 192, is a list of railroads and giving the amount of oil used in various applications.

At the bottom of this page is given a list of railroads with tabulation of the type and operation of various oilers.

The detailed statement opposite page 190 showing the organization for use of ballast cleaning machines should have been opposite page 188 as part of the ballast cleaning report.

This report on use of oil spraying machines is submitted as information, with the recommendation that the subject be discontinued.

Mr. J. V. Neubert:—I have great admiration for Mr. Knowles and his Committee, but I hope they don't do this. That is one of the live subjects in America. One of the big problems I had when I attended the International Railway Congress in 1930 was the non-corrosive conditions of track structures and bridges that they had in Europe, and the unfortunate condition we have to contend with in America. One of the things we have to contend with in this country is the rapid corrosion of track and bridge structures. We have learned a lot about it, but I think we are in our infancy.

We are one of the roads that has been oiling very extensively. My good friend, Mr. Ray, of the Lackawanna, has done it more than we have.

I think the subject of applying this oiling of track fastenings should be continued, because at least for the ten years we have been doing it we think we know something, but I think we have a lot to gain, and I believe your Committee can teach us something. Therefore I would like to see this referred back to the Committee on Outline of Work for consideration

Mr. Robert H. Ford (Chicago, Rock Island & Pacific):—I will be glad to second Mr. Neubert's motion.

Chairman C. R. Knowles:—We will be very happy to consider the subjects further.

The President:—Do I understand they remain with this Committee, or referred to the Committee on Outline of Work?

Mr. J. V. Neubert:—This subject, as well as the other two subjects, I suggest be referred back to the Committee on Outline of Work for consideration.

Mr. Robert H. Ford:—If the Committee, as the Chairman has indicated, are willing to withdraw their recommendations and take the subjects back, God bless them! I seconded Mr. Neubert's motion because I was afraid if I did not it might be lost on the floor, and the Committee would drop the subject.

While I am on my feet, I want to say that if any instructions to the Board are needed, it should be to supplement the membership of this Committee by the very best men in the Association. If there was ever a time when the railroads needed the very best brains obtainable on this Committee, they need them now. So far as dropping any subject is concerned, goodness gracious! we can not afford to drop any subject. I want to supplement and endorse all Mr. Neubert has said.

I was glad to hear Mr. Walling. He just took the wind out of my sails, as a matter of fact. The idea of dropping those subjects at this time! It is the best opportunity this Committee has ever had, in this time of severe depression, to find some way whereby we can utilize our work equipment to decrease our operating costs. I hope there is no subject the Committee has this year that they will drop.

If the Chairman wants to keep these subjects on, I am going to withdraw my second to Mr. Neubert's motion, and I am satisfied that the Board will be glad to let them continue these subjects.

Chairman C. R. Knowles·—It was not the thought of the Committee that these subjects be dropped for all time, but there are so many timely subjects for consideration that it was thought best to drop some of these for the time being at least, and proceed with others of equal if not greater importance. However, if it is the wish of the Association, we will be very glad to continue the subjects.

The President:—Have you anything more to say, Mr. Neubert?

Mr. J. V. Neubert:—No, sir. I know Mr. Knowles will satisfy this Association.

(The motion was put to vote and carried.)

Chairman C. R. Knowles:—That concludes our report, Mr. Chairman.

The President:—I think you have done a good piece of work. You have had four out of five recommendations approved for the Manual, and you were able to drop four out of five assignments you were trying to get out of working on. Thank you very much (Applause).

DISCUSSION ON RULES AND ORGANIZATION

(For Report, see pp. 337–347)

Mr. E. H. Barnhart (Baltimore & Ohio):—The report of the Rules and Organization Committee is found in Bulletin 342, beginning at page 337.

The first subject assigned to your Committee is Revision of Manual, collaborating with appropriate Committees. Revision of Manual is found in two Appendices A and B, starting with page 339, and will be presented by the Chairman of the Sub-Committee, Mr. P. D. Coons.

Mr. P. D. Coons (Chicago, Burlington & Quincy):—At the convention last year, Committee XVI—Economics of Railway Location, presented a very complete report on the subject of the proper size and character of field organizations for railway location and construction, with a recommendation that the subject-matter in the Manual, with the material which they were offering, be consolidated and coordinated through collaboration with Committee XII. This has been done during the past year, and the results of the coordination appear on page 339, in which you will find the material in

the Manual on the left, and the proposed form on the right. The Appendix explains which is new material and which has been modified. The article on construction at the end of Appendix A is entirely new and is confined largely to the personnel of construction parties.

I referred a minute ago to the fact that we had collaborated with Committee XVI, and the form as presented has their approval. If there are no objections, I would like to move that the proposed form covering the modifications in and additions to the Manual be approved for inclusion in the Manual.

The President:—We have a motion before the house that the personnel of locating and construction parties be as outlined by Mr. Coons. Is there any discussion on this?

(The motion was put to vote and carried.)

Mr. P. D. Coons:—Under Appendix B, continuing on page 343, we have indicated proposed changes in the wording, principally in describing the titles of rank of Division Engineer and below. The change, you will note, is largely cutting out repetition of words, as "the title assigned" as now appears in the Manual, substituting the shorter form as it appears on the right.

I move that the proposed form for these titles be included in the Manual, substituting these for the old form.

The President:—Is there any discussion on this question?

(The motion was put to vote and carried.)

Chairman E. H. Barnhart:—The second subject assigned to your Committee is Rules for Maintenance of Bridges—Steel Structures, and will be presented by Mr. A. B. Griggs, Chairman of the Sub-Committee.

Mr. A. B. Griggs (Atchison, Topeka & Santa Fe):—The report of the Sub-Committee appears on page 344 of Bulletin 342, under Appendix C and Appendix D.

Appendix C covers Rules for Maintenance of Bridges—Steel Structures. There are thirteen rules submitted for approval and printing in the Manual as recommended practice. These rules have been before Committee XV—Iron and Steel Structures, and have their approval. They are the same as presented by the Committee at last year's convention. By numbers, they are as follows: 1100, 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1110, 1111 and 1112.

I move that these be adopted for printing in the Manual as recommended practice.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Mr. A. B. Griggs:—Appendix D covers seven proposed Rules for the Maintenance of Bridges—Masonry, and are submitted as information.

The Committee, however, suggests a change in Rule 1153, as follows: "Areas of masonry that have become disintegrated to an extent which tends to weaken the strength of the structure must be repaired by patches of sufficient thickness and thoroughly cured, the following general principles being observed." The general principles appear in the Bulletin on page 344. This is submitted as information.

The President:—If there is no objection to that, it will be so ordered.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—I wrote Mr. Barnhart calling attention to the fact that the Masonry Committee was assigned the subject of preparing a specification for disintegrated or deteriorating concrete, which is now contained as a tentative specification in the Masonry Committee's report, and is of much greater extent than that shown in this report.

In addition to that, I want to call attention to the fact that where a structure or any part of a structure has deteriorated you must have, in addition, a design calling for a plan for rehabilitating that structure for the purpose of carrying the load for which it is designed.

Mr. A. B. Griggs:—The Committee has Mr. Hirschthal's comment that he refers to, but we did not have the report of his Committee at the time this was written, and had no information as to what his Committee was going to present. But in view of the work of this Committee, that of preparing rules for maintenance, we feel warranted in retaining the proposed Rule 1153 in our report. We did modify the language to meet some of the criticism that was offered, but we do not feel that we should withdraw the rule in its entirety.

Mr. Meyer Hirschthal:—I want to make the point that when you get to the part of maintenance, taking a structure and trying to maintain it when it is past the point of being strong enough to carry what it is designed for, you are not within the province of maintenance.

Mr. A. B. Griggs:—I might say further that it is the intention of this Committee to submit these rules to the Committee on Masonry before they are presented to the convention for adoption. You will appreciate that the material we have in the Bulletin now is offered as information, not for final adoption. We will be glad to cooperate with you, sir, and adopt whatever suggestions you may make that this Committee can approve.

Mr. Meyer Hirschthal:—I wanted to make those suggestions in advance.

Mr. A. B. Griggs:—We do not expect to put these rules before the convention for adoption without first referring them to your Committee.

Mr. W. P. Wiltsee (Norfolk & Western):—I think the Committee has omitted one very important rule. I do not see anything relative to proper care of expansion joints. I know of several cases where considerable damage was done in long concrete structures, where the expansion ran all to one point. I suggest that the Committee consider this recommendation.

Mr. A. B. Griggs:—We would be glad to receive any suggestions for further rules of maintenance of masonry. We recognize that what we have presented here is very brief and incomplete. We welcome a suggestion for a rule along that line.

Chairman E. H. Barnhart:—May I say just a word to Mr. Hirschthal, the Chairman of the Masonry Committee, concerning these seven rules which have been proposed? Possibly we should not have printed them in the Bulletin, before we submitted them to the Masonry Committee, as we recognize of course that the Masonry Committee are more qualified to prepare such rules. We will be very glad to cooperate with his Committee in any way in order to find rules for maintenance of masonry which will be acceptable.

The next subject, Rules for Maintenance of Other Terminal Structures, will be found in Appendix E, page 345, and will be presented by Mr. B. R. Kulp, Chairman of the Sub-Committee.

Mr. B. R. Kulp (Chicago & Northwestern):—Rules for Maintenance of Other Terminal Structures, which appear on page 345, for turntables and oil houses, are just supplementary information. At the last convention, rules were approved for inclusion in the Manual, and we were treated somewhat like the preceding Committee. We were requested by one of the members to go into the rules further to see if we could make some additional rules.

The four rules on turntables and one on oil houses are additional information in line with that suggestion, and are submitted as information at this time. I so recommend that it be treated as information.

The President:—If there is no objection to that disposition of this question, that will be done.

Chairman E. H. Barnhart:—The third subject, under the general heading of Rules for the Guidance of Employees of the Maintenance of Way Department, has to do

with the maintenance of telegraph and telephone lines. The Chairman of the Sub-Committee is not present, but he has collaborated with the Sub-Committee of the Telegraph and Telephone Section of the A.R.A., and the two Sub-Committees have reached an agreement on the method of procedure. If this meets with the approval of the Telegraph and Telephone Section, A.R.A., the Sub-Committees will work together, and this Committee hopes to have some information to submit to the Association next year.

Subject (3) assigned to the Committee is found in Appendix F, Titles Employed to Designate Positions of Corresponding Rank in Maintenance of Way Service, subordinate to that of Division Engineer. The report will be presented by Mr. Richard Brooke, Chairman of the Sub-Committee.

Mr. Richard Brooke (Chesapeake & Ohio):—The assignment of this Sub-Committee is divided into two parts: Part I, Titles Employed to Designate Positions of Corresponding Rank in Maintenance of Way Service, Subordinate to that of Division Engineer; Part II, Recommend Proper Titles for Positions now Assigned to Assistant Engineers in Departments other than Maintenance of Way.

Under Part I, the titles shown in Appendix F were offered as information last year and printed in the 1931 Proceedings. These are listed under two headings: Assistant Engineers, Maintenance of Way Department; Formen, Maintenance of Way Department.

The Committee now offers these titles in Appendix F for approval and printing in the Manual, and I so move.

The President:—You have heard Mr. Brooke's motion. Is there any discussion on the subject or any questions you want to ask?

(The motion was put to vote and carried.)

Mr. Richard Brooke:—Appendix G. The titles shown in Appendix G are for positions below the rank of foreman in the Maintenance of Way Department, and were selected from a summary of replies to questionnaires sent to 33 of the principal railways of the United States and Canada. The majority of these titles are more commonly used than equivalent titles of corresponding rank, and some of them have been in general use by the Association in the past.

It is the sense of the Committee that these titles are proper to designate positions of corresponding rank in Maintenance of Way service, and to promote uniformity in nomenclature. The Committee offers these titles as information.

The President:—If there is no objection, they will be so received.

Mr. Richard Brooke:—Part II of the assignment recommends proper titles for positions now assigned to Assistant Engineers in departments other than Maintenance of Way. Progress has been made by your Committee in endeavoring to suggest the proper title for the position of Assistant Engineer in departments other than Maintenance of Way, but the Committee is not in position to submit a report at this time. A questionnaire was sent to a number of representative railways, and replies received to date contain some interesting data which the Committee is now analyzing.

The President:—It will be so received, Mr. Brooke.

Chairman E. H. Barnhart:—Subject (4), Rules for Fire Prevention as Applying to Maintenance of Way Department, collaborating with the Railway Fire Protection Association, has been before this Committee for three years. We have finally succeeded in working out some rules which are tentative, and which we present at this time. Mr. W. C. Mack, Chairman of this Sub-Committee, will present the report.

Mr. W. C. Mack (Civil Engineer):—The rules the Chairman spoke of are found on pages 346 and 347 of Bulletin 342. They pertain to duties of divisional supervisory officers. They have been taken up with the Railway Fire Protection Association, and we have their tentative approval of these rules. Of course, this is only the start and

we expect to go ahead next year on duties for foremen and positions below that. These rules only cover the duties of Division Engineers, as you will note, Rule 302; supervisors of track, Rules 316 to 319; supervisors of bridges and buildings, Rules 374 to 379–b; supervisors of water service, Rules 423 to 425; supervisors of telegraph and telephones, Rules 609 to 613.

These rules are offered only as information. It is just the start of the subject. We would be very glad to get any suggestions from members of the Association, as it is rather a large and complicated subject. As I said before, it is just the beginning, and you will notice that at the end of each classification the rule says: "They must know that all their foremen understand and rigidly observe all fire prevention rules." Of course those rules are not yet made. They are going to be made next year and, as I said before, these are just rules for supervisory forces. This Sub-Committee offers them as information at this time.

Mr. W. A. Radspinner (Chesapeake & Ohio):—The basic rules of fire protection are rules laid down by the National Fire Protection Association, from principles formulated by the National Board of Fire Underwriters of the Underwriters Laboratories. I happen to be a member of the National Fire Protection Association, and also the Railway Fire Protection Association, to which Mr. Mack referred.

On our railroad (I happen to be Superintendent of Fire Prevention of the Chesapeake & Ohio), as on all large roads, we have a Book of Rules, which embody these basic principles but which are made to cover all the different departments. This Book of Rules is then signed by the President. We do not confine ourselves to a set of rules for each department, because if we did they would be continually passing the buck and saying this or that rule did not apply to them.

I have written down some of the objections I have taken to some of the Committee's recommendations.

1. Co-operation. It seems to me that the proposed rule releases from responsibility the rank and file and places it all on the supervisory forces. I think it should cover the whole field, so I would suggest the following:

"The protection of the property of the (of this) railroad against fire is an important part of the duty of every employee and each will be held responsible for the property in his charge or in which he is employed.

"Where any of the rules or requirements are not being observed, it is the duty of each employee noticing the same to make immediate report to his officer."

2. One of the most important features of fire prevention is to prevent a recurrence of a fire, and the best manner of doing this is by prompt investigation. Therefore, I would suggest the following paragraph covering this part of the subject:

"Each fire, however small, must be reported at once to the proper officers and thoroughly investigated by the Fire Prevention Department and Division officers, so that, if possible, its cause may be determined and future fires prevented. (Each department should be represented on the Investigating Committee, with the Division Superintendent Chairman)."

3. Article 302—Division Engineers. I do not know of any railroads where the Division Engineer lays out the terminal and designs the buildings. On our railroad such matters are handled by the Chief Engineer and the Resident Engineer. It certainly is not a Maintenance of Way duty. It would seem to me that it would be the duty of the Superintendent of Fire Prevention to collaborate with the Engineering Department on all such proposed construction when the plans are being prepared. That should be one of the principal duties of a Fire Prevention Engineer.

4. Article 375. If this paragraph covers only the Maintenance of Way shops, all well and good, but if it covers Maintenance of Equipment buildings, there will surely

be a conflict. These two departments just will not stand for criticism from the other on standard practice. This should be a department requirement.

5. Supervisors of Bridges and Buildings. These men should be responsible for recharging all fire extinguishers other than Maintenance of Equipment at shops, where they should be recharged by the Local Fire Chief.

They should also be responsible for water barrels and fire buckets and should originate requisitions for replacements.

They should also be responsible for Maintenance of Way camp car equipment when in their territory.

6. Rule 379. It is my opinion that the Division Superintendent, the Superintendent of Fire Prevention, or the District Fire Prevention Inspector, is the best man for that job because the city authorities know these men, especially the latter, carry the responsibility for fire protection and have that subject very much at heart while the Division Engineer is a departmental head and most of them cannot see anything but ties, rails and ballast.

7. Rule 609. Supervisors of Telegraph and Telephone. I doubt very much the wisdom of placing the responsibility of maintaining a shop fire alarm system on the Signal Department. This should be under the supervision of the Electrical Engineer, who, with his local shop and road forces, are required to pass examination of the National Electrical Code and city ordinances, are better able to install and maintain such equipment.

Mr. W. C. Mack:—Regarding your remarks on cooperation, we really have not got that far down on the scale yet, you might say. In other words, these are only supposed to cover rules for supervisory forces. When we get down as far as section foremen and lower positions, we will be glad to go into that. We would be glad to have you submit anything in writing that you have in mind. There are a good many different positions on different railroads, and these things could be handled by different men.

The President:—My understanding is that your Committee will be glad to give Mr. Radspinner's remarks full consideration.

Mr. W. C. Mack:—Yes, sir.

The President:—Does anyone else have anything to discuss, or suggestions to make?

Chairman E. H. Barnhart:—In reply to Mr. Radspinner would state that the subject we have assigned to us is "Rules for Fire Prevention as Applying to Maintenance of Way Department." Under that subject, we could hardly extend to other departments.

It is unfortunate he did not submit his suggestions to us before the convention, as we could probably have incorporated some of them in the rules. However, as I stated before, we have had this subject under consideration for three years, and I am free to say that the majority of the subject-matter was taken from the Railway Fire Protection Association Manual.

Mr. W. A. Radspinner:—The Railway Fire Protection Association has not held an annual meeting for some time. They passed their annual meeting in 1931 and the committee collaborating with Mr. Mack's report is composed of insurance men, one of whom never worked on a railroad and another has been in the insurance department so long I doubt if he knows anything about Operating or Maintenance of Way rules.

The President:—It is going to be a great help for the Maintenance of Way people to have those rules. We are appreciative of your good work. We are glad Mr. Radspinner gave you something to work on next year, and we will now excuse you with our thanks (Applause).

DISCUSSION ON GRADE CROSSINGS

(For Report, see pp. 497–508)

Mr. J. G. Brennan (New York Central):—The report of Committee IX is contained in Bulletin 343, page 497.

On the first subject, Revision of Manual, Appendix A, Mr. P. M. Gault is Chairman. Unfortunately, Mr. Gault is ill and is not able to be here. I will therefore present the report for him:

"(a) The illumination of highway crossbuck signs by means of the use of reflecting buttons.

"This assignment has been subject to study and consideration by the Committee during the year. The Committee recommends that the subject be continued.

"(b) The proper location of the whistling post in view of the modern tendency of traffic crossing highway crossings.

"Recommendation: The Committee recommends that the present practice of locating whistle post one-quarter (¼) mile from the grade crossing be continued. In special cases, where local conditions require, distance of whistle post from crossing may be varied, if not in conflict with law. To be received as information.

"(c) The proper lighting of the base of signals where located in the center of the highway.

"Conclusion: The Committee is of the opinion that the proper lighting of base of signals where located in center of highway is adequately taken care of by present A.R.E.A. standards. To be received as information, and the subject assigned for further investigation during the coming year.

"(d) The illumination of advance warning sign for railroad crossings.

"Recommendation: The Committee recommends that the present standard advance warning sign as shown in Fig. 6, page 664 of the Manual, 1929, be revised to provide that the letters 'R R' and the Cross '(+)' be illuminated by means of reflecting buttons, as illustrated in the accompanying sketch (Exhibit A)."

Since this action was taken by the Committee, Mr. A. H. Rudd of the Signal Section has advised me that a Joint Committee on signs has been formed of the American Association of State Highway Officials and of the National Conference on Street and Highway Safety. It is thought best to recommend that this Association approve this sign and refer it to the Association of State Highway Officials for adoption by that committee as a standard highway sign. This sign is distinctly a highway sign, and it is felt that that committee should adopt it.

"(e) Revision of wording in A.R.E.A. Bulletin 337 of July, 1931.

"The Committee recommends that the first word of the second line in item No. 4, page 64, 'Highway Crossing Signs and Signals,' of A.R.E.A. Revisions and Additions to the Manual, Bulletin 337 of July, 1931, be changed from 'may' to read 'should'," so that the sentence will read: "At crossings where wigwag or flashing light signals are used, one should be placed on each side of the track."

The President:—My understanding of the recommendations is that the Manual is to be changed as outlined by you.

Chairman J. G. Brennan:—I make a motion to that effect.

Mr. Robert H. Ford (Chicago, Rock Island & Pacific):—On what section is the motion made?

The President:—Appendix A.

Mr. G. J. Ray (Delaware, Lackawanna & Western):—I understood, from your presentation, that you proposed to refer this advance warning sign to the Standard Road Committee.

Chairman J. G. Brennan:—The Joint Committee of the American Association of State Highway Officials and the National Conference on Street and Highway Safety.

Mr. G. J. Ray:—You do not, then, wish to have that included in the Manual?

Chairman J. G. Brennan:—No; the recommendation is that it be not included in the Manual, but that it be approved by this Association and referred to that committee.

Mr. G. J. Ray:—Then I am opposed to the approval of it, if that is the recommendation of the Committee. In the first place, I do not think the colors are right, and I think that is what the committee will tell you when you refer it to them. Why not let it go until you get their recommendation before you make it a part of our Manual?

Chairman J. G. Brennan:—I believe these colors, Mr. Ray, are in accordance with their recommended colors.

The President:—Wouldn't it be satisfactory to your Committee to first submit this to that committee, and then another year recommend your conclusions to the Association?

Chairman J. G. Brennan:—Perhaps it would. Our thought is that if approved by this Association it would have more weight with the highway officials as adoption of standard for them.

Mr. Bernard Blum (Northern Pacific):—It seems to me it would be advisable for this body as an Association to recommend to the Association of Highway Commissioners their views on this subject, this being a recommendation of the A.R.E.A. to the Highway Department, which shows our wishes in the matter. This sign is in line with our present standard advance warning sign, with the addition of the self-illuminating buttons, and I think as such will have considerable weight with the Highway Commissioners. At the present time, the Highway Commissioners have two standards for the advance warning sign: one, with the single horizontal bar; the other, with two horizontal bars. It is our thought that they should limit their advance warning sign to the single horizontal bar, similar to our present standard.

Mr. J. C. Irwin (Boston & Albany):—I should like to ask what relation this action would have to the bulletin of the American Railway Association for recommended standards, "Bulletin No. 1, Railroad Highway Grade Crossing Protection." Would that be an amendment to that?

Chairman J. G. Brennan:—That would be an amendment. This was adopted by the American Railway Association at its meeting last fall. This sign has been adopted, which is another reason, I think, for this Association approving the sign. It has been adopted by the Joint Committee of the American Railway Association.

The President:—Is there any further discussion, gentlemen?

Mr. A. H. Rudd (Pennsylvania):—Answering Mr. Ray, the idea of referring this to the American Association of State Highway Officials for recommendation was in order to head off their suggestion that it was none of our business. We recommend it to them because we have to furnish the signs in nine cases out of ten. I think they will accept our recommendation with very good grace, whereas if we put this in the Manual they will ignore it, perhaps.

The President:—Are there any further suggestions? You have a motion before you.

(The motion was put to vote and carried.)

Chairman J. G. Brennan:—The second subject is Comparative Merits of Various Types of Grade Crossing Protection. Mr. W. C. Pinschmidt is the Chairman.

Mr. W. C. Pinschmidt (Chesapeake & Ohio):—The report of the Sub-Committee appears on page 498, Bulletin 343.

Relatively few new protective devices haye come to the attention of the Committee during the past year.

On pages 499 and 500 are listed briefly five types of grade crossing protection which have been considered. There is one correction to be made on page 500, under item 2,

the second paragraph. The word "nine" should be inserted to make the first sentence read: "The battery consists of nine dry cells, three series, three parallel, giving 4½ volts." It is recommended that the report be received as information.

The President:—Unless there is some objection, the report will be so received.

Chairman J. G. Brennan:—Subject (3), Appendix C, Economic Aspects of Grade Crossing Protection in Lieu of Grade Separation. Mr. G. P. Palmer, Chairman of the Sub-Committee, will present the report.

Mr. G. P. Palmer (Baltimore & Ohio Chicago Terminal):—This Sub-Committee has been engaged for the past two years in assembling cost data covering the annual cost of various types of paving on highway crossings, signs, and various types of crossing protection. During the last year we sent out a questionnaire to ten representative railways for additional information, but received replies from only four. This information was so incomplete that we did not feel we were warranted in reaching any conclusion, so it is recommended that the subject be continued for further investigation and study during the coming year.

The President:—Unless I hear objection, it will be so ordered.

Chairman J. G. Brennan:—Subject (4), Appendix D, Methods and Forms for Classifying Highway Crossings of Railways and Forms for Recording and Reporting Highway and Railway Traffic over Highway Grade Crossings.

The form prepared by the Sub-Committee is in Appendix D on pages 501 and 502 of Bulletin 343, and was developed with the idea of furnishing a complete description of each individual crossing, highway and railway. It is recommended for printing in the Manual.

The traffic record forms, appearing on pages 503 and 504 of Bulletin 343 are designed to give complete traffic record of both highway and railway traffic by hours, with delays occasioned by each railroad movement over the crossing. It is the belief of your Committee that the information gathered by employing these forms would be of use in cases of agitation for grade crossing elimination, and possibly as a basis of cost allocation in the event of elimination.

It is recommended that these forms be printed in the Manual.

Mr. Robert H. Ford:—I would like to ask the Committee if they, in considering these forms on page 504, methods and forms for classification of highway crossings, took into consideration the probable cost of preparing that data.

Chairman J. G. Brennan:—I do not know that there are any figures developed on the cost.

Mr. Robert H. Ford:—I would gather not. There are 28 questions there, and I would say that it is an excellent outline for a young engineer to go out and make a survey, but to use those as a record by the railroads and its adoption in the Manual is about the best course I know of to pursue to have it a dead letter.

The railroads in one of the western states, at the request of the State Highway Commission, undertook the preparation of a complete synopsis of questions on their particular railroads. I was interested to find out what it cost. The Rock Island was one of the participants. The cost was a very large sum of money to all of them.

That was followed later on by a request by another western state. We found it was going to cost somewhere between $1,500 and $2,000. It cost more than that for our railroad to collect it in the other state. That is all right if it is valuable, but it is not. I had it on the authority of two Chief Engineers of two state commissions that from 30 to 40 per cent of the existing crossings on the average western and southern railroads are unnecessary.

I think the questions in this questionnaire (its purpose is good fundamentally) could be reduced, if desired, to not over six, possibly ten, and they should be predicated upon the principle of the elimination entirely of the crossing. Your questionnaire is not predicated on that basis whatsoever. It is predicated more on the theory of separating the crossing or of protecting the crossing. The data to be collected is predicated on an erroneous assumption.

The average grade crossing is a potential cost to railroads of from $5,000 to $10,000 a year. I want to say that there is no more fruitful opportunity for you to reduce your operating expenses than by the elimination, the closing, of these unnecessary grade crossings. If you will stand on the rear of a train some day, just note how many could be combined. We have confronting us in this country an expenditure of from 25 to 40 million dollars annually by railroads for grade separations, and the astonishing fact that grade crossings, in spite of all we are doing, are continually increasing. I want to say that the responsibility for that is pretty largely up to the railroads themselves. It is purely an economic question and fundamentally, I think, it rests with your Committee to develop proper outlines whereby railroads can be informed on the excessive cost of continuing an excess number of grade crossings.

So far as this form is concerned, I think, fundamentally it is all right in principle, but it is wrong in application, and wrong in its method of preparation. It is predicated, as I said before, as I read the questions, on the theory of keeping the crossing, whereas it should be predicated on the theory of finding such information as would be necessary to get rid of the crossing.

I move, unless the Committee wish to take it, that this be referred back to the Committee.

Mr. V. R. Walling (Chicago & Western Indiana): The form on page 503 does not strike me as being such an expensive form on which to prepare the information as Mr. Ford has indicated.

Mr. Robert H. Ford:—I am talking about the form on pages 501 and on page 502, the first one under item 4, Methods and Forms for Classifying Highway Crossings of Railways. The second one is Forms for Recording Information. I am speaking of the first. The 28 questions is what I am addressing my remarks to.

Chairman J. G. Brennan:—Mr. Ford, perhaps you are right in saying that this form has been developed more with the idea of grade crossing elimination in mind than it has of deferring it, but in the East grade crossing elimination is a very live subject and whether the railroads will or no they have to go to the hearings. They are brought up before the State Commissions on grade crossing elimination proceedings, and practically all the information shown in this report is required in one way or another at the hearings, and oftentimes such information is very valuable to the railroads in opposing grade crossing eliminations. It gives a true picture of what the crossing is, and what the conditions are. Very often it helps in determining the division of cost.

Mr. Robert H. Ford:—The remarks of the Chairman are a further indication that this should be referred back to the Committee. The average number of crossings will run about one to the mile. Assuming that the average railroad is 2500 miles, which is conservative, that means 2500 forms prepared to protect against several isolated cases. No question of this kind coming before any commission presents a special study of itself. I do not think this Association wants to adopt a form that would require it to collect and record information on 2500 or 3000 unnecessary, largely, crossings to take care of a few.

The opening paragraph says: "Information should be obtained by field inspection and from records. It should be compiled on ground in tabular form which should be

filled out, dated, and certified as correct by the Engineer making the inspection. Information shall be compiled for all grade crossings of highways, local roads and streets by operating divisions serially in the order of mileposts."

If this was prepared by the Federal Government, or some bureaucratic arrangement of that kind, I would have no objection to it, but when it is required that this Association is to go on record as recommending to railroads that we prepare 2500 or 3000 of these forms for filing away to protect against four or five cases, I want to say I am against it. It is wrong and should not be done. If the Association adopts it, it is nothing more than a dead letter. We cannot afford it, and it should not be done.

I hope the Committee will not press this thing on the floor, and that they will withdraw this for further study. Potentially, it is all right, but it is wrongly prepared and has the wrong angle. A year of study will make a far different impression.

Mr. A. H. Rudd (Pennsylvania):—I do not understand that it is the province of the American Engineering Association to instruct the railroads in the use of the form. You cannot tell a railroad to fill out a form for a lot of crossings. This is a tentative form, as I get it, to be used where necessary to get information as to certain crossings. Then it is to be decided as to the best way to handle it. Under 24, the different kinds of protection provided, and under 25, re-location of the highway; also separation of grade, by vacation or closing and diversion of traffic.

Mr. J. C. Irwin:—This is requested for a purpose, where you want information regarding grade crossings. Judging from Mr. Ford's remarks, his objection is that the form must be made out for every grade crossing. I think the form is useful for reference where one wants the information in one's files, but I have to suggest that on page 501 the last sentence of the preamble be omitted, where they say: "Information shall be compiled for all grade crossings of highways, local roads and streets by operating divisions serially in the order of mileposts." It seems to me that might be omitted, and the form might be useful for the reference of those who wish information on certain definite grade crossings.

Mr. Bernard Blum:—I do not believe I disagree with Mr. Ford in some of his views. I, personally, for my railroad, would not start out and make such a survey for all the crossings on the Northern Pacific. We have some 5000, 6000 or 7000. I do not take it that this form was prepared with that idea in mind. We were directed by the Committee on Outline of Work to prepare a form that would cover classifying of highway crossings with railroads. Our work followed those directions, in that we have included all of the elements which seem pertinent to such a classification.

As Mr. Rudd brought out, the question of elimination by diversion, re-location, and so forth, is covered in the form. As brought out by Mr. Irwin, it can be applied and used for such crossings as we have in mind to take care of at the time.

Chairman J. G. Brennan:—One further object in making this form was to help the railroads who had a great deal of grade crossing elimination work to do, to determine the order in which the crossings should be chosen. I think with the suggestion that the word "all" be eliminated from the last sentence of this form, it will prove a useful form. It does not necessarily mean it should cover all crossings. Each railroad can use it where and when it wishes to.

The President:—My understanding of Mr. Irwin's suggestion was that that whole sentence be left out.

Chairman J. G. Brennan:—There is no harm in leaving the entire sentence out. The Committee is satisfied to move that the last sentence of the heading be removed. I make the motion that it be removed.

Mr. E. S. Butler (Kansas City Southern):—On page 594 of Bulletin 344 this same form appears in the report of the Records and Accounts Committee, and that Committee on page 591 recommends that the form be used only in connection with special investigations.

The President:—By eliminating the last sentence of the preamble.

Mr. E. S. Butler:—Then the two Committees would be in agreement, I think.

Mr. Robert H. Ford:—Will you please read the elimination? I do not seem to find it readily.

Chairman J. G. Brennan:—At the top of the form, page 501, under the words "Division . . . Branch," the last sentence: "Information shall be compiled for all grade crossings of highways, local roads and streets by operating divisions serially in the order of mileposts."

Mr. Robert H. Ford:—I do not like to speak any more on this subject, but I wish the Committee would be willing to take this back for another year. The form is not complete. As I said before, it has been predicated upon the wrong assumption. The questions are good, but if, as the Chairman has said, this is to be used in grade crossing cases, the presumption on one of the questions is—let me just read it: "Is elimination of grade crossing feasible?" The answer is yes.

Let us assume that my figures are reasonably correct, that 30 to 40 per cent of the crossings ought to be closed entirely. What do you want to separate it for?

I ask that this form be referred back to the Committee for further study. I have no objection to the form in principle, but I say the form as it is, is faulty. It will aid it a whole lot by cutting out the line you suggested, but it is a very important matter, gentlemen.

Railroads are today confronted with enormous expenditures on this highway crossing problem, and I urge you to take this form back and give it further study, because we are approaching a question in this country where if railroads have got to live there has to be some way found on this question of expenditures for public improvements, notably that this question of highway and grade crossing separations shall be more equitably apportioned. I do not believe in collecting information and filing it. In the first instance, it is relating to crossings that never should be there at all. Your form does not touch that at all. It is not predicated upon that principle, as the Chairman well said at the start.

If a motion is in order, I move that the form be referred back to the Committee for further study.

The President:—So as to get myself clear, Mr. Ford, is it not to be decided the probabilities are that there is to be grade elimination, or has been ordered by state, city or municipality, and this form is to get the necessary data in connection therewith? Your proposition is a study to see what might be done for the elimination of grade crossings by totally eliminating the crossings?

Mr. Robert H. Ford:—Yes, sir.

Chairman J. G. Brennan:—This form is for the information of the carrier itself. It does not necessarily have to be filed with the Public Service Commission or a state body. This is for the carrier itself to classify its own crossings.

Mr. Robert H. Ford:—I still call the attention of the Committee to the fact that they are asking to have a form filled out for every crossing on these railroads, including a very large per cent of crossings that should not be there at all. I think the work should be taken back.

The President:—I thought Mr. Irwin's suggestion, which the Committee agreed to, eliminating the last sentence of the paragraph of the preamble, took care of that

point; that is, that it is not intended or suggested that it be made compulsory for every crossing, that it be made for a particular crossing only if and when the information is wanted, and that it is a good form to use for that purpose.

Mr. Robert H. Ford:—If that is true, it relieves a large part of the difficulty. I still insist that even so the form is not complete for the purpose for which it is intended, and further study is well justified under the conditions under which we have to work.

Mr. H. L. Ripley (New York, New Haven & Hartford):—I wonder if Mr. Ford read Section 25, Paragraph c—502, where one of the functions provided for is elimination by vacation or closing; diversion as well as separation of grades.

Mr. Robert H. Ford:—Yes, I have read it.

Mr. W. P. Wiltsee (Norfolk & Western):—I think this form covers the whole situation. As I see it, question 26 says, "What percentage of highway traffic can be diverted by re-location?"

As I understand it, the motion was to adopt these forms as recommended practice with an amendment offered to eliminate the last sentence of the preamble so that it would not be compulsory to secure this data for all crossings.

Mr. J. C. Irwin:—Further in defense of the work of the Committee, I believe they have studied this more than a year already and that they have a pretty comprehensive idea of what constitutes a complete form. With the elimination of this sentence the form can be used when wanted and does not have to be used at all when not wanted. Therefore, I think it is a useful addition to the Manual.

Mr. S. S. Roberts (Interstate Commerce Commission):—I am just wondering if Mr. Irwin made his statement as a suggestion or as a motion.

Mr. J. C. Irwin:—Mr. Roberts, I made a suggestion to the Chairman of the Committee, and he accepted it for the Committee. My idea was that as he presents the motion to adopt, it will eliminate the sentence which I suggest be eliminated.

Chairman J. G. Brennan:—That is correct.

Mr. S. S. Roberts:—The motion before the house now is Mr. Ford's motion, is it?

The President:—Mr. Ford's motion has not been seconded.

Mr. Robert H. Ford:—I do not want to press the point. I realize the Committee have done good work on this. I realize if they want to send somebody out to make a survey on these cases that is going to involve $50,000 or $100,000. If they want to send an outline of that in there and trust to somebody to pick out the data, the Rock Island will not use it for that purpose. There is too much money involved in it. The Committee has done some excellent work, and if they feel that is the best they can do, I have nothing more to say.

Mr. S. S. Roberts:—The motion is that the report of the Committee be adopted, with the elimination of the last sentence in this preamble. Is that right?

Chairman J. G. Brennan:—That is correct.

Mr. S. S. Roberts:—I would like to make an amendment to that, that item 25 read: "Is the elimination of this crossing feasible?" You can have various kinds of elimination and that would cover the whole situation, whether it be the closing of the crossing or whether it be elimination by separation of grades.

Chairman J. G. Brennan:—You would insert the word "this"?

Mr. S. S. Roberts:—I would change 25 to read: "Is the elimination of this crossing feasible?"

Mr. Robert H. Ford:—I would like to ask Mr. Roberts if he would not add the words "and closing"—"Is the elimination and closing of this crossing feasible?" Elimination of a crossing, and closing a crossing are two different things.

Chairman J. G. Brennan:—Closing is elimination.

Mr. Robert H. Ford:—The elimination and closing of crossings are two different things. Sometimes two crossings come together and combined. The crossing is not eliminated.

Chairman J. G. Brennan:—We have closed a great many crossings, and they are considered eliminated when they are closed.

Mr. G. J. Ray:—Might I ask whether the Committee would be satisfied to change the heading in putting this in the Manual, if you please. No. (4) reads: "Methods and Forms for Classifying Highway Crossings of Railways and Forms for Recording and Reporting Highway and Railway Traffic over Highway Grade Crossings." If we could cut out everything in that sentence, you would eliminate all the trouble Mr. Ford has been talking about. You will not need to make this report, but the way the problem is put up to them it looks like a classification of all crossings. By cutting that part of the sentence out, and the sentence which we have cut out in the heading, it seems to me you have eliminated Mr. Ford's trouble.

Chairman J. G. Brennan:—The way the heading is worded is the assignment given to the Committee. We are perfectly willing to change it.

Mr. G. J. Ray:—If it is put in this manner, I see no objection. It does not require classification of all the crossings. It is a fact that the way this subject was presented to the Committee they were requested to submit a form for classifying all grade crossings.

The President:—Mr. Ray, does it not answer your question? As I understand it, it will be in the Manual under the heading "Form for Recording Highway Grade Crossings, North and South Railway." That is the way it goes in the Manual, anyway.

I think maybe the heading as you expressed it—we will see a lot of ghosts in it.

Mr. Robert H. Ford:—I have no objection to Mr. Ray's suggestion.

The President:—The motion, then, is that this form be approved. Before doing that, however, Mr. Roberts wanted to make a suggestion on 25. We did not dispose of that, I think.

Mr. S. S. Roberts:—My motion was not seconded, so I suppose you do not have to worry over it.

The President:—Perhaps the Committee will accept it without any second.

Chairman J. G. Brennan:—I think the Committee is willing to accept that: "Is elimination of this crossing feasible?"

Mr. S. S. Roberts:—I think it will eliminate Mr. Ford's trouble.

Mr. Robert H. Ford:—If the Committee will include "closing" too.

Mr. S. S. Roberts:—Subject (4) is the subject assigned to the Committee, and the title of the form as somebody has said, should be, and is, "Form for Recording Highway Grade Crossings, North and South Railway."

Chairman J. G. Brennan:—That is also acceptable to the Committee.

The President:—To get back, Mr. Ford would like to ask the Committee to make No. 25 read: "Is elimination or closing of this crossing feasible?"

Chairman J. G. Brennan:—I can see no objection to that, either.

Mr. W. S. Lacher (Railway Age):—Suppose that is changed that way, and the answer is yes, what would be meant, elimination or closing?

The President:—Why should the answer be yes? Whoever may be answering would have to answer the question.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—I am not quite clear whether Mr. Roberts' suggestion of adding the words would do away with (a), (b) and (c) under 25.

Chairman J. G. Brennan:—That answers the whole thing, I would say.

Mr. C. W. Baldridge:—If the suggestion made by Mr. Roberts is put in as a heading, and (a), (b) and (c) remain in the form, then you are answering one of the three. You do not answer the suggestion made by Mr. Roberts without taking into consideration the three sections (a), (b) and (c). Was it your intention to publish the (a), (b) and (c) as shown by the Committee?

Mr. G. R. Westcott (Missouri Pacific):—It seems to me that if Mr. Roberts' suggestion for a change of this item would not eliminate the word "grade," then Mr. Ford's suggestion that there is a difference between the "closing" and "elimination" would be eliminated, if you please. In other words, if you make the question read: "Is elimination of this grade crossing feasible?" it amounts to the same thing as closing.

The President:—The only reason Mr. Ford wanted "closing" was that he wanted to emphasize closing.

Mr. C. W. Baldridge:—The suggestion made by Mr. Roberts is already shown here under 25, page 501: "Is elimination of grade crossing feasible?" No. 25 on page 502 adds to the words, "Is elimination of grade crossing feasible?" and on page 502 (Article 25) under "(a) By re-location of highway; (b) By separation of grade; (c) By vacation or closing and diversion," which covers everything that could be prepared.

Mr. Louis Yager (Northern Pacific):—It seems to me we are a little unfair to the Committee. They were given a definite assignment to classify highway crossings, and they have given the information that is characteristic of each, and then, under 25, page 502, they classify these highway crossings with respect to the disposition that can be made of them. It seems to me the Committee have fulfilled their assignment, and by eliminating that last sentence in the heading you have taken away any objection that might be raised with respect to the too general application of this form, as Mr. Ford has pointed out, by making it burdensome. I believe the Committee have fulfilled their instructions and a good deal of this discussion is beside the point, because there is a classification provided for.

The President:—The question is before you.

Mr. S. S. Roberts:—May I interrupt? I have no objection to item 25 on page 501 as it stands. I made my suggestion with the hope of smoothing Mr. Ford's ruffled spirit a little bit. It seems to me that the explanatory note 25, on page 502, answers the questions that have been brought up. It shows the character of elimination. That word "elimination" is a broad term. I do not think it is necessary to use both "elimination" and "closing." If definition of the word "elimination" is desired, the Committee has shown in note 25, page 502, the different ways that elimination may be brought about.

(The motion was put to vote and carried.)

Mr. Robert H. Ford:—Before you leave Appendix D, I would like to ask the Committee if before presenting the second form, which is a very excellent one, they discussed the matter with any of the state commissions or the Federal Bureau of Roads. I speak of that for this reason: There is a growing tendency on the part of state commissions to present diversified testimony on the necessity for grade crossing elimination. The statistics of a crossing are a very valuable part of the evidence. On the other hand, as you gentlemen know, when these matters come before the state commissions for action, it is too late; the project has already been approved by the Bureau of Public Roads.

I know the Bureau are quite anxious to have unanimity of action in so far as the traffic centers are concerned. I have no criticism on the form, but I feel before its adoption it would be well to endeavor to enlist the support of the state highway authorities, and particularly the Bureau of Public Roads. If that is true, it gives it a

far more effective character and is in line with what the Committee are endeavoring to do in the standardization of general grade crossings.

I make that as an inquiry, as to whether the Committee have done that or not.

Chairman J. G. Brennan:—In answer to that, I will say that Mr. H. D. Blake, a member of this Sub-Committee which developed this form, is a member of the State Highway Commission of the State of Wisconsin; he is the Engineer of Grade Crossings of that commission. I am unable to say whether the Chairman of the Sub-Committee, who is not here today, discussed it with any of the members of the National Highway Committee or not.

Appendix E, Subject (5), Methods and Principles for Determining the Order in which Protection, Elimination, and Separation of Grades at Highway Grade Crossings should be Undertaken. Mr. Bernard Blum, Chairman of the Sub-Committee, will make the report.

Mr. Bernard Blum:—This subject was approached in rather a general way, and we gave considerable thought to the question of preparing formulae that would give the answer, but that did not seem wise on account of the changing conditions that prevail throughout the country. As brought out in the report, which is rather in the form of a thesis, questions which have been brought out in previous discussions, namely, the necessity for considering the crossings in a community or in a state as a whole should be given due weight and a consistent program worked out from which individual crossings could be considered as necessity arose.

The formulae which have been brought to our attention, while seemingly very clever, are fraught with a good deal of inconsistencies and dangers. Practically, the recommendations of the Committee are contained in Paragraphs 9 and 10 on page 506, which call for a complete study of the industrial traffic and the traffic situation of the community as a whole.

After the report was prepared, there was brought to our attention an article written by Mr. John P. Hallihan, Chief Engineer of the Rapid Transit Commission of Detroit, who, while not a member of the Sub-Committee, is a member of the General Committee. In that article Mr. Hallihan brought out how this problem was met in the city of Detroit and worked out along the lines recommended by the Committee. Therefore, this article was included as an addendum to the report to show how practically it can be met.

The report is presented to you as information and no definite action, we believe, is required on the part of the convention.

The President:—Unless I hear objection, that will be so received.

Chairman J. G. Brennan:—It may be of interest to the members of the Association to know that the American Railway Association's Joint Committees on Grade Crossing Protection have published in pamphlet form the recommended standards for grade crossing protection which were adopted by the convention last year. They have sent this bulletin to all the utilities commissions of the various states, to the highway commissions, and to all the railroads as recommended standards, and the committee now has a campaign under way in an endeavor to secure adoption by all the states.

That completes the report of the Committee, and I move the report be accepted.

(The motion was regularly seconded, put to vote and carried.)

The President:—Mr. Chairman, we want to thank you for the very complete and thorough report you have submitted. The fact that you have stirred up some considerable discussion in the membership makes it doubly interesting. You are now excused with our appreciation (Applause).

DISCUSSION ON RIVERS AND HARBORS

(For Report, see pp. 207–241)

Mr. E. A. Hadley (Missouri Pacific):—We have a lack of Sub-Committee Chairmen present tonight. Mr. Kirkbride, of San Francisco, wrote he would be unable to be present, and I have a wire from Mr. Fristoe saying that he was enroute to the convention but was stricken with ptomaine poisoning and had to stop off at St. Louis.

Your Committee was divided into three Sub-Committees to better consider and handle the work assigned to it. The Chairman of Sub-Committee (1), Definitions of Terms, whose report is shown as Appendix A, is Mr. W. C. Swartout. I will ask him to present the report of that Sub-Committee.

Mr. W. C. Swartout (Missouri Pacific):—I believe the opening paragraphs of the report of the Sub-Committee on page 208 outline our recommendations.

As the speaker said a year ago, we earnestly request those of our members who are interested in the kind of work which Committee XXV is reporting on to go over Appendix A with two thoughts in mind, to-wit: First, question any definition appearing in the report which seems to you to be indefinite, ambiguous, or does not adequately cover the meaning of the word as commonly used in your locality; second, suggest any word used in this class of work in your locality which does not appear in the report, giving us the definition as used. Any assistance of this kind which you render will be of great value to the entire membership. A few members assisted us last year, and several have done so since Bulletin 341 appeared. To those members our sincere thanks are extended.

As the report in Appendix A is to be received as information and further study given the entire subject during the coming year, I believe no action on the part of the convention is required.

For the benefit of the membership, I would like to call attention to a few typographical errors in the printing of our report. On page 210, in the definition of seagoing hopper dredge, near the end of the third line, it says: "This type developed for work of ocean bars." It should be "on ocean bars."

Further down on the same page, dredge work, scow measurement, "of scow leads" should be "of scow loads".

On page 213, the fourth definition, waling piece, in the second line the word "by" should be "to," and the word "or" should be inserted in front of "to the main structure by a vessel," so that the definition would properly read: "A timber on the water side of a pier, wharf or quay to prevent damage to a vessel or to the main structure by a vessel."

I believe that is the report of the Sub-Committee.

The President:—If I hear no objection, this will be accepted as recommended by the Committee as progress.

Chairman E. A. Hadley:—I neglected to mention a fourth Sub-Committee, which is headed by Mr. A. F. Blaess, Chief Engineer of the Illinois Central, who is also unable to be present as he is in New Orleans trying to control the floods in the Mississippi River, particularly through the Bonne Carre spillway. The subjects handled by Mr. Blaess' Sub-Committee are: (2) Recommend Suitable Types of Construction for Levees, Dikes and Mattresses for use under varying service conditions, giving consideration to Stream Alinement, Sub-Surface, Soil or other Local Conditions; and (3) Submit Specifications for the Construction of the Several Types of River Bank Protection in Common Use.

Report of the Sub-Committee, Appendix B, Subject (2), appears on page 213 of Bulletin 314 and is devoted to the discussion of the application of various kinds of flood protection work, comprising a summary or amplification of subjects submitted in 1930 and 1931, and is presented at this time as information.

Appendix B, Subject (3), specifications covering hydraulic methods of levee construction, appearing on pages 215 and 216, and specifications for net cross-section levees without banquette, appearing on page 216, are submitted as amendments to specifications for levee construction, appearing on page 1346 of Bulletin 324, and are submitted as information and for consideration by the membership with a view to including it in the Manual at a future date as part of the specifications appearing on pages 1346 to 1350 inclusive, Bulletin 324.

Specifications for woven willow mattresses, appearing on page 217; specifications for pole and brush bank mattress, page 218; specifications for pole brush and rock dikes on page 219; specifications for brush fascines on page 221 are all submitted as information and for further consideration by the membership with a view to their adoption as recommended practice, and for inclusion in the Manual at a future date.

The President:—Is there any discussion on this, gentlemen? Are there any questions you would care to ask? If I understand then, it is the recommendation of your Committee that this report be considered as information, to be changed or amplified so as to be put in the Manual at some future time, but not in the Manual this year.

Chairman E. A. Hadley:—That is correct.

The President:—In other words, a progress report. That being the understanding, and if there is no discussion or objection, it will be so handled.

Chairman E. A. Hadley:—Your Committee recommends that the specifications submitted in 1931 covering loose fascine mattress, board mattress, mud seal, riprap bank paving and anchor piling be adopted and approved for printing in the Manual.

I move that those specifications that were submitted last year, and which have been under consideration for the past year, be adopted.

The President:—Is there any discussion on this, gentlemen?

(The motion was put to vote and carried.)

Chairman E. A. Hadley:—Subjects (4) and (5), Different Types of Bulkheads, Jetties and Seawalls, giving cross-sections of each and stating the purpose which they serve, including Comparisons of First Cost, Service Life and Maintenance Cost of the various types; Different Types of Fender Systems for Protecting Wharves and recommend suitable uses for each, including Comparisons of First Cost, Service Life and Maintenance Cost of the various types, were assigned to the Sub-Committee, of which Mr. Fristoe was Chairman.

We wish to submit the reports under Appendix C as information, and the subjects kept open for further study and consideration of the Committee with a view to making more definite recommendations at the next annual meeting.

The President:—Is there any discussion on this? If there is no objection, it will be so disposed of.

Chairman E. A. Hadley:—Subjects (6), (7) and (8) were assigned to the Sub-Committee of which Mr. Kirkbride was Chairman.

Subject (6), Types of Warehouse Piers, Coal and Ore Piers, Car Float Piers and others with Recommendation as to the Type Suitable for Use Under Various Conditions, including Comparisons of First Cost, Service Life and Maintenance Cost of the Various Types.

(7) Recommend Size and Depth of Slips Required for Economical Operation of the Various Types of Wharves and Traffic Conditions, including Comparisons of First Cost, Service Life and Maintenance Cost of the Various Types.

(8) Harbor Structures.

Your Committee has collected a considerable amount of data on these subjects which is included in Appendix D accompanying our report.

We recommend that this material also be accepted as information and the subjects continued for the further study of your Committee with a view to making more definite recommendations at the next annual meeting.

The President:—Gentlemen, I am sure the Committee would welcome an opportunity to answer any questions you may have to promulgate, or be pleased to have you discuss the matter in any way you see fit. If there are any suggestions, I hope you will take the time and pains to bring them out now. Apparently there is no discussion, but if you have any suggestions that occur to you later, I hope you will give this Committee the benefit of those suggestions in writing.

Chairman E. A. Hadley:—The Chairman of the Committee would appreciate receiving suggestions, as suggested by the President. This is rather a broad subject, and in some ways it is rather specialized and we would appreciate information and suggestions from the membership.

That constitutes the report of the Committee.

The President:—Mr. Hadley, we very much appreciate the work of your Committee. There apparently is no further discussion desired or necessary at this time. The report of your Committee shows that the formation of the Committee was justified, and the subject one of keen and special interest to many members of this Association. With that, you are excused with our thanks (Applause).

DISCUSSION ON ROADWAY

(For Report, see pp. 297–335)

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—Report of the Committee on Roadway will be found in Bulletin 342, beginning on page 297.

Owing to the financial stringency and business depression existing in the country during the past year, it was not convenient to hold committee meetings as freely as in past years, and some members found it impossible to give time to the committee-work which was necessary to prepare a report. For these reasons, the Committee reports progress on three subjects, (6), (7) and (11), as assigned to us for the year's work. We have nothing to offer on these subjects this year. The Committee on Outline of Work has been asked to reassign these subjects for next year's work, which they have done, and we hope to have some valuable reports on them to submit to the next meeting of the Association.

The subjects assigned to this Committee for this year's work, and the action of the Committee thereon are as follows:

Revision of Manual—The report of the Committee on Revision of Manual will be found in Appendix A, and Mr. A. E. Botts, Chairman of the Sub-Committee, will submit the report.

Mr. A. E. Botts (Chesapeake & Ohio):—The report of this Committee, as you have been told, is found in Bulletin 342, page 298. Of the subjects that were considered for revision, only one, specifications for concrete fence posts, is ready for your consideration.

In the interest of brevity and to eliminate duplication, revised specifications have been prepared. Since the proposed specifications have been published in the Bulletin, several criticisms have been received and in line therewith various substitutions are

offered. Under "(a) The following specifications covering the manufacture of concrete fence posts and drawn up in collaboration with Railways Bureau of the Portland Cement Association, are submitted for substitution of the specifications appearing on pages 68, 69, 70 and 71, 1929 Manual," we wish to add the following words "Committee VIII—Masonry, of the A.R.E.A." after "Portland Cement Association."

Under "Proposed Form" on page 298, Materials, we wish to strike out this entire paragraph and substitute the following:

"Cement, aggregate, water and metal reinforcement shall conform in quality to the specifications for concrete of the A.R.E.A. as given under the subject 'Masonry' with the following exceptions:

"New billet steel used shall be of hard grade;

"The maximum size of aggregate shall be not more than three-fourths the distance from reinforcement to outside of post.

"Reinforcement bars made of rerolled rail steel may be used.

"Reinforcement shall be in the form of round or square bars or cold drawn steel wire.

"Crimped, stranded or flat reinforcing shall not be used.

"When choice can be made between sizes of reinforcement, it is preferable to use the larger number of smaller bars."

This replaces all the items that are in the former specifications down to "Proportioning and Mixing." There is no change in the Bulletin under proposed form in the paragraphs covering "Proportioning and Mixing."

Under "Manufacture" in the proposed form we have various subjects: Molds, Placing Reinforcing, Compacting, Finish, and Curing. Under the subject of "Curing" we wish to strike out the original paragraph and substitute the following:

"Curing shall start immediately after placement of concrete and shall extend for the following periods of time depending upon the temperature being maintained with reasonable uniformity during the curing period.

Approximate Temperature Degrees Fahr.	Curing Period in Days
50	14
70	10
90	7
120	2

"Temperatures exceeding 140 deg. Fahr. must not be used. No evaporation or other loss of moisture from the concrete shall be permitted during the curing period, or while cooling off after heat curing." (See Tests.)

"Inspection Tests." Omit the last sentence beginning with the words, "The same test applied to finished post," and so forth.

Patents—No change.

With these changes in the proposed form, your Committee recommends that these specifications be printed in the Manual to take the place of those now in existence. I so move that this be done.

The President:—Gentlemen, you have heard the recommendation of the Committee that this report be included in the Manual as recommended practice in place of the former specifications for concrete fence posts. Is there any discussion on the subject?

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—I would like to have Mr. Botts read me the revised specifications on curing. I did not quite get that.

(Mr. Botts re-read the revised specifications on curing.)

Mr. Meyer Hirschthal:—I understood that was to be revised so that the curing period in days covers the removal of the form rather than the period of curing. That was my understanding from the letter I received from Mr. Botts.

Mr. A. E. Botts:—I can only answer that in this way, that it would appear unnecessary to keep these posts in forms until they are entirely cured. It would increase the expense of manufacture unnecessarily. We thought it would probably meet your approval in this form.

Mr. Meyer Hirschthal:—The idea I had in mind was this: This refers particularly to the higher temperatures of heat curing. While the post is sufficiently steam cured after two days at a temperature of 120, it is not cured. There must be some treatment to the post other than steam curing during the period. We do not want the post to lose its moisture too fast in the steam curing. My objection to this table was to be met by a slight change, I understood, and I do not see it in the way it is given now.

Mr. A. C. Irwin (Portland Cement Association):—The whole purpose of the specification in question is to secure proper curing. It is not to regulate the time the forms shall be kept on. It is wholly immaterial when the forms are taken off, just so the specification for adequate curing is followed.

The specifications under "Tests" contains a very drastic provision for the condition of a post after two days' curing at 120 degrees as follows: "The same test applied to finished post after drying at 70 degrees Fahr. for 60 hours shall show an increase in weight of not more than 1 per cent."

Under "Curing" also is the statement: "No evaporation or other loss of moisture from the concrete shall be permitted during the curing period, or while cooling off after heat curing." That takes care of the curing of the post after the heat treatment at 120 degrees.

It seems to me that this specification has adequately taken care of everything that might happen.

Mr. A. E. Botts:—I have a letter sent to Mr. Fritch from Mr. A. M. Bouillon of Cincinnati on this, which I think would be appropriate to read at this time:

"In looking over the Bulletin for December, 1931, I find on pages 302 and 303 a short item covering the curing of concrete, which therein applies especially to reinforced concrete fence posts. May I draw attention to the following conditions applicable to the curing of any concrete:

"(1) Evaporation of the water placed in the concrete mixture is most intense during hot weather, or as a result of overheating the aggregates and water prior to mixing; therefore, those are the conditions that require the most careful and consistent curing. However, for temperatures of 90 degrees Fahr. your proposed period of curing is reduced to 7 days and for 120 degrees Fahr. it is cut down to 2 days. Whether these temperatures refer to the weather or to heated mixtures is not made clear. In the latter interpretation it is my belief, backed by much practical experience, that no concrete mixture should exceed 75 degrees Fahr. when placed. It should preferably range between 55 degrees and 70 degrees Fahr. A much higher heat may be applied *to the outside* after the concrete has been poured providing it is a *moist heat,* such as curing with steam in a housed structure.

"(2) All authorities, I believe, agree that water continuously maintained for a period of 10 days to 2 or 3 weeks, or even longer, as the case may require, is the most ideal method of curing. In freezing weather, steam is the most satisfactory method. I have used combined steam heating and curing on structures in Canada when the outside temperature reached as low as 68 degrees Fahr. below zero and obtained excellent results on both items. The mission of curing is to develop as much as is reasonably possible of the potential strength contained in the structure. The overheating of aggregates and water results in accelerating the hardening, but unless evaporation is prevented by proper curing, a porous concrete will result that in time will be less strong and less durable.

"(3) Proper curing insures a much higher percentage of strength than that obtained from any other element of the mixture, including use of the water cement ratio. Improper curing, therefore, means a serious loss of potential strength that could have been easily retained, in most instances, at a trifling extra cost. It is my opinion that

this subject requires greater emphasis than is usually given in specifications or applied in practice.

"(4) In your proposed form no definition of curing is given. Would it not be advisable to explain this item more fully? There are still some Engineers who confuse curing with hardening or aging and some who apparently do not know that the purpose of curing is to insure development of the process of hydrolysis, by preventing the evaporation of the water contained in the mass required to insure progressive and uniform hardening.

"In the May, 1931, Proceedings of the American Society of Civil Engineers, William M. Hall calls attention to the fact that more than 50 per cent of the concrete made and placed is of poor quality and will have but a short life. I thoroughly agree with Mr. Hall and believe the reason largely due to lack of proper curing. Practically every city and district of the United States has cement structures—some completed recently—that are not complimentary examples of engineering and construction. It is evident that much promotional work of a real *practical* nature is required to obtain more uniformity and better quality of concrete."

The President:—Is there any further discussion, gentlemen?

Mr. A. C. Irwin:—I think most of us could subscribe quite thoroughly to what Mr. Bouillon has said. It is very good, but the provisions of these specifications meet with his requirements. The paragraph I just read under "Curing" says that no loss of moisture shall be permitted during the process of curing. That is what he says. Certainly, there is no criticism of the specifications contained in Mr. Bouillon's letter.

Mr. Meyer Hirschthal:—In regard to this, I want to put myself on record as objecting strenuously to the appearance of an item of a two-day curing period at a temperature of 120 degrees.

Chairman C. W. Baldridge:—In connection with the subject of curing, after the Committee had received some letters on the subject I looked through the Manual to see what curing meant. The Masonry Committee, I believe, has not defined the term curing. Neither did I find that our Masonry Committee has provided for curing any kind of concrete. The only other Committee, aside from the Roadway Committee, that attempted to provide for curing of concrete, as I remember it, was the Electricity Committee in providing specifications for concrete poles.

I suggest to the Masonry Committee that they take some action on this subject themselves next year.

Mr. Meyer Hirschthal:—I can say that this action has been taken.

The President:—Are you ready for the question?

(The motion was put to vote and carried.)

Chairman C. W. Baldridge:—The second subject assigned to the Roadway Committee is Roadbed Drainage. This subject has been under consideration by the Roadway Committee for the past two or three years prior to this one, with sections of the subject brought in and adopted.

This year the Sub-Committee's report is found on page 304. Mr. G. S. Fanning, Chairman of the Sub-Committee, will present the report.

Mr. G. S. Fanning (Erie):—We have gone on from where we left off last year and have taken up this year the subject of sub-surface drainage. This report is recommended for inclusion in the Manual. I will read it simply by sub-headings except paragraphs on which we have had some written discussion.

"Definition," leave out the four words "may be defined as"; substitute a period and a dash to follow the usual form for a definition.

Under "Soil Moisture" in the next to the last line the word "proportion" has been changed to "ratio".

No changes under "Soils". No changes under "Field Test for Soils". No changes under the fifth section, "Necessity for Drainage." No changes under "Water Cut-off:"

"Drainage of Open Soils;" "Drainage of Impervious Soils;" "Pipe Drains—(a) Location; (b) Grade."

Under this item, the word "better" in the second line should be changed to "greater".

"Pipe Drains—(c) Depth; (d) Size; (e) Laterals; (f) Kind."

On this paragraph we have a written discussion from Mr. J. S. Huntoon, Assistant Bridge Engineer of the Michigan Central. He says: "Suggest omitting detailed comparisons of the two materials," that is, vitrified pipe and corrugated galvanized perforated iron pipe, making the paragraph read as follows:

"Two materials now are available, each of which if properly laid fulfill these conditions. These are (1) vitrified clay pipe sewer tile with bell ends and (2) corrugated galvanized perforated iron pipe. The determination as to which to use may depend on local conditions.

"The criticism is that other materials may at any time be put on our markets; that material prices are subject to continual change and that the discussion of suitability under various local conditions is not advisable as matter for the Manual."

It is the opinion of the Committee that to give the Engineer the information necessary to judge as to what to do under any local conditions is important, and we think we have done that in the last paragraph, which reads:

"The determination as to which to use will depend on local conditions and on the relative costs. Vitrified clay pipe will usually cost less than corrugated iron pipe and is preferable where the excavation is of any considerable depth into firm material or where the water carries sulphur or other chemicals in quantities injurious to iron pipe. Corrugated iron pipe is preferable where the cover is shallow or the material unconsolidated and where vitrified pipe might be subject to breakage or its alinement disturbed by accident or heaving. Corrugated iron pipe is ordinarily not used in sizes smaller than 8 inches in diameter."

Mr. J. L. Pickles (Canadian National):—I would like to ask if the Committee has given any consideration to the use of cedar box drains. We find that cedar box drains outlast drains made of any other material.

Mr. G. S. Fanning:—Where can cedar be obtained?

Mr. J. L. Pickles:—Principally on the Canadian National Railways.

Mr. G. S. Fanning:—I thought so. We used to have cedar box drains up there, but I thought it was hardly an important enough material now to mention in the Manual because it is so scarce except in Canada. Of course they have other things in Canada that we do not mention in the Manual either.

If there is no further discussion on that paragraph, I will go on with the next one. "(g) Trench." We desire to strike out the words in the third line, "through drainage".

Mr. Huntoon has also said that he thinks we ought to say in this paragraph, "Selected material should be used for backfill," but I call attention to the fact that that is practically said under Paragraph (m), where we say "The entire trench should be backfilled carefully with a selected permeable material," so I think that point is already covered.

"(h) Foundation; "(i) Installing Tile Pipe;" "(j) Installing Corrugated Iron Pipe;" "(k) Outlets; (l) Risers;" "(m) Backfilling."

As to this paragraph, Mr. Hunton says, and voices what others have said: "Suggest omitting the second sentence for the following reason: Engine cinders do not constitute a homogeneous or dependable material. Cinders is a residue, partly soft ash. Its value is always questionable. It frequently deteriorates in use, holds water and disintegrates with frost action and no two shovelsfull are alike. The value of shrinkage

is too great to nullify or endanger it by use of questionable backfill, the best of which is ultimately most economical and no other kinds should have mention in the Manual."

The Committee feels that they have rather damned engine cinders by faint praise already. We say: "Engine cinders should be used only when no other satisfactory material is available, but never with corrugated iron pipe on account of the corroding effect of the sulphuric acid which is present in the cinders." I think it is better to mention it and tell its weaknesses than to simply ignore it.

Mr. J. L. Pickles:—Would it not be better to leave out the word "satisfactory"? Engine cinders cannot be considered satisfactory material.

Mr. G. S. Fanning:—It is satisfactory if you cannot get anything better. You could say, "If no other material is available you can put the same stuff in that you take out." That is deplorable. I would much rather backfill a trench with engine cinders than put back the stuff taken out of the trench.

Mr. J. L. Pickles:—Would you agree to screened engine cinders then? If the fine material is screened out, cinders may be used.

Mr. G. S. Fanning:—I would not object to that. We are not advocating cinders very strongly, but they are used so much we feel that something ought to be said about them so as not to have them used where they ought not to be used.

The President:—Would it not take care of both suggestions if you would substitute for "Where no other satisfactory material is available . . ." the wording, "where no better material is available"?

Mr. G. S. Fanning:—We will accept that. With those corrections the paragraph would read: "The entire trench should be backfilled carefully with a selected permeable material, such as clean crushed stone or washed gravel. Screened engine cinders should be used only when no better material is available, but never with corrugated iron pipe on account of the corroding effect of the sulphuric acid which is present in the cinders."

Paragraph "(n) Time;" "(o) Record;" "(p) Inspection."

The Committee recommends the adoption of this report for publication in the Manual, replacing the following existing material: "Page 41 '(5) Pipe drains should be provided for the drainage of wet cuts,'" and I so move.

The Committee recommends that the subject "Roadbed Drainage" be continued.

The President:—You have the motion before you for discussion. Is there any further discussion?

(The motion was put to vote and carried.)

Chairman C. W. Baldridge:—The third subject assigned to this Committee reads: Influences Affecting the Life of Fence Wire and Methods for Prolonging the Service Life of Fence Wire. Mr. W. C. Pruett, Chairman of the Sub-Committee, will present the report.

Mr. W. C. Pruett (Missouri–Kansas–Texas):—This report is set forth in Bulletin 342 on page 309, and is submitted as information only. It is recommended that the subject be continued for further study.

The President:—If there is no objection, it will be so handled.

Chairman C. W. Baldridge:—The fourth subject assigned to this Committee is Permanent Roadbed Construction. Mr. W. G. Brown, Chairman of the Sub-Committee, will present the report.

Mr. W. G. Brown (Florida East Coast):—The report of this Sub-Committee will be found on pages 310 to 313 inclusive of Bulletin 342.

Consideration of this assignment has been undertaken annually since 1926, and descriptions of various types of permanent construction have been embodied in previous reports. With the exception of the Lehigh Valley's tunnel section, described in this

report, the Committee has been unable to develop any additional data of value during the past year.

It is recommended that the report be considered as information only, and that the subject be discontinued until the present installations have been in service a sufficient length of time to develop other valuable data.

The President:—Are there any comments on these recommendations? If not they will be so handled.

Chairman C. W. Baldridge:—The fifth subject assigned to this Committee reads: Specifications for Overhaul in Grading Contracts and a Recommended Method for Calculating Overhaul. This subject has been a bone of contention in this Association ever since the Association was formed, I find, and inasmuch as the Sub-Committee Chairman who was first assigned to handle this topic was unable to give time to it, he withdrew from the work quite late in the season, and the Chairman attempted to handle it in the short time remaining.

Since the report has been put into print, I have had opportunity to go through a considerable amount of the Proceedings of this Association, from Volume I up toward the present time, and I found a great deal of very valuable information there. I also find there are a few bugs in the report as it is now printed, and for that reason the Committee has decided to offer the Specifications for Overhaul in Grading Contracts, beginning on page 315 and extending to page 321, as information, and recommends that the subject be reassigned for further work.

The President:—If there is no objection offered to this recommendation, it will be so handled.

Chairman C. W. Baldridge:—Subjects (6) and (7) are reported as progress. (8) Use of Highway Crossing Planks and Substitutes Therefor. Mr. Oyler, Chairman of this Sub-Committee, wired me he was unable to be present owing to stormy conditions in the East which had caused a considerable amount of heavy work in his territory and kept him at home. I will therefore call your attention to the report of the Sub-Committee found on page 322 of Bulletin 342. This covers data on different types of crossings, this being a continuation of the activities of the previous years, the thought being that information covering such a large number of crossings when finally tabulated will contain information of considerable value in helping railway officers in determining the relative merits of plank and substitutes therefor. Requests for data were sent to a large number of carrier representatives, but responses were few, and it is hoped that more favorable consideration will be given the Committee's work this year. It is realized that to be of value data must be separated between light and heavy traffic, not only on the railways but also on the highways. One of the Sub-Committee's recommendations is that the data be shown in square feet instead of track feet, and this will be given consideration.

The report is offered as information, and request has been made that the subject be reassigned, which the Committee on Outline of Work has done.

The President:—If there is no objection, it will be so accepted.

Chairman C. W. Baldridge:—Subject (9) also reports progress. Subject (10) Means of Protecting Roadbed and Bridges from Washouts and Floods. Mr. H. M. Swope, Chairman of the Sub-Committee, will present the report.

Mr. H. M. Swope (Atchison, Topeka & Santa Fe):—This report is to be found in Bulletin 342, pages 325 to 330 inclusive.

To avoid conflicting with the work of Committee XXV—Rivers and Harbors, the work of this Committee was confined to streams which are not classed as navigable and

to avoid unnecessary repetition, details of design of protection works which come under Committee XXV is not included.

The Committee recommends that the material now existing in the Manual, page 40, under "Washouts," items 1 to 5 inclusive, be replaced by this report, which is as follows: (I will read the sub-headings, as in the text of the report they are shown by letter only.) "Outline: Scope—Importance:

"I. Permanent Protection
- 1. Bridges
  - (a) Sufficient waterway
    - Length
    - Approach openings
  - (b) Relations of character of materials to water erosion
  - (c) Depths of foundation and protection from scour
  - (d) Prevention against stream erosion threatening new channels around bridges
  - (e) Protection at ends of boxes and culverts
  - (f) Protection for head of bank in trestles and trestle approaches
  - (g) Drift catchers
  - (h) Levees to collect water and confine to bridge openings
- 2. Fills
  - (a) Sufficient overflow openings
  - (b) Anchoring track
  - (c) Protection of embankment subject to overflow
  - (d) Wave action
  - (e) Flow of water through fills
  - (f) Side washes
    - Streams
    - Surface Ditches

"II. Temporary Protection
- 1. Bridges and Culverts
  - (a) Sand bags, etc.
  - (b) Drift
- 2. Fills
  - (a) Side washes
  - (b) Erosion in overflow
  - (c) Wave action."

Mr. President, I move this report be accepted for inclusion in the Manual, replacing the material included under "Washouts," items 1 to 5 inclusive, page 40 in the 1929 Manual.

The President:—Is there any discussion on this, gentlemen? There seems to be none. The question, therefore, is before you.

(The motion was put to vote and carried.)

Chairman C. W. Baldridge:—Subject (12) Heaving Track. Subject (12) is one which was handled by this Committee last year and reported as information. By instruction of the Committee on Outline of Work, the Committee were asked to bring in this report again this year, with the recommendation that it be included in the Manual.

Mr. C. S. Robinson, Chairman of the Sub-Committee, was unable to be here, and I will therefore read the headings in the report, as has been done with the other reports.

"Cause and prevention of heaving of track, due to frost action and maintenance methods while the effects of heaving are present." Sub-headings: "Cause;" "Prevention;" "Maintenance Methods."

Mr. J. L. Pickles:—Having had my objection sustained as to cinders, I would also like to see the phrase "two feet" on page 331, changed to read: "Subgrade being removed to a suitable depth".

The President:—Does the Committee accept that?

Mr. J. L. Pickles:—I object to the use of engine cinders in the track, and the inclusion of the phrase "removed two feet." This may be all right in a hot country where you do not have frost enough to kill your pumpkin vines; serious heaving does not occur until the frost is more than two feet deep.

Chairman C. W. Baldridge:—"Where heaving occurs in isolated places on fills, much may be accomplished by digging out these places, the subgrade being removed two feet or more. . . ."

Mr. J. L. Pickles:—We should have more than two feet in depth.

Chairman C. W. Baldridge:—We have given you all the latitude you want—"two feet or more."

Mr. J. L. Pickles:—That is all right. I do not want cinders in my track, either.

Chairman C. W. Baldridge:—Locomotive cinders seem to be one of those track materials which differ greatly in different parts of the country. The soft coal locomotive cinders, common through the central part of the United States, make a very good bottom for a lot of bad track and have been used a great deal in years gone by. It is very true that in some places locomotive cinders are of very little value, perhaps in the hard coal country. Also, I believe that locomotive cinders where machine stokers are used and the coal is powdered, or something of that nature, are usually very poor, but the old hand-fired soft coal cinders were pretty good stuff for drainage. Naturally, the question of the use of cinders depends on the cinders, just as the various kinds of slag differ.

I made an assertion from the floor two or three years ago about slag, and was called for it. After a little further investigation I found, like the statement made about cinders a minute ago, that no two slags seem to be alike. That, to a certain extent, is the condition of cinders. There are cinders and cinders. Some of them are good, and some of them are bad.

I do not believe it is necessary to eliminate cinders entirely. It might be well to give an option there, cinders or other permeable material.

Mr. J. L. Pickles:—Why not leave cinders out and say "porous materials"?

Chairman C. W. Baldridge:—It is agreeable to say "porous materials" instead of cinders.

Mr. P. C. Newbegin (Bangor & Aroostock):—We have done a considerable amount of digging out of frozen humps and have used cinders to a large extent to fill in with. We have had better results with cinders than with gravel, or any other material we have tried. We are in a country where at times it is quite cold.

Chairman C. W. Baldridge:—The Committee will accept the suggestion to use the words "porous materials" instead of "cinders," if that is satisfactory. Are there any further suggestions?

"Maintenance Methods." On page 332 there is a copy of the standard plan of the Canadian National Railways showing their practice in shimming of heaved track, and on page 333 are some shims as they are used, both shims and braces, standard plans of the Maine Central Railroad.

Mr. Chairman, I move the adoption of this report for inclusion in the Manual.

The President:—You have the report before you. Is there any further discussion?

(The motion was put to vote and carried.)

Chairman C. W. Baldridge:—The thirteenth and last subject assigned to this Committee reads: Specifications for Pipe Line Crossings Under Railway Tracks. Mr. P. T. Simons, Chairman of the Sub-Committee, will present the report.

Mr. P. T. Simons (Missouri Pacific):—Specifications for Pipe Line Crossings Under Railway Tracks, as proposed in this report, pages 334 and 335, Bulletin 342, describes

the principal features and dimensions of specifications now in use on railways which furnished information to the Sub-Committee.

Pipe Lines considered are those conveying oil, gas, gasoline and other inflammable substances, steam, or liquid at pressure. The data available to the Sub-Committee were reasonably complete, but no railway specification contained all features and dimensions proposed, so the plan is a composite one. The essence of the plan is that pipe lines be encased in a larger pipe entirely across railway right-of-way. The purpose of this construction is to protect railway property against injury by leakage from or failure of the pipe line on or near railway right-of-way.

Since the report was adopted by the Roadway Committee and printed in Bulletin 342, Committee XX, which expects to embody whatever specifications the Association adopts as part of an agreement form, has suggested holding the matter over for another year to permit, if possible, preparation and presentation of a report to which the American Petroleum Institute will not object.

This Sub-Committee has been informed that the American Petroleum Institute at present believes the provision for installing valves in the pipe line, one each side of crossing, should be omitted. That matter will be given further study.

Another feature which will be studied further is the distance between pipe lines and underground electric wire conduits. The proposed minimum of 8 feet may be too great, and the Committee believes the point can be covered by specifying suitable insulation.

For these reasons, the report as printed is now submitted as information with the recommendation that the subject be reassigned.

The President:—If there are no objections to that procedure, it will be handled in that way.

Chairman C. W. Baldridge:—This finishes the report of the Committee on Roadway.

The President:—Mr. Baldridge, we always look forward with keen interest to the report of this Committee, realizing we will get valuable information and data, and we are most appreciative of the splendid work you have done. You will now be excused (Applause).

DISCUSSION ON STRESSES IN RAILROAD TRACK

(For Report, see pp. 369–370)

Dr. A. N. Talbot (University of Illinois):—The report of the Committee on Stresses in Railroad Track is found in Bulletin 342, December, 1931. It contains a statement concerning the work in the field, laboratory, and office which has been done during the past year and the progress made toward getting this material in shape for presentation. As it is presented as information only, Mr. President, I judge that action on it is not needed.

The Secretary asked me sometime ago if I would speak at this evening's meeting on some topic on stresses in track, and in a moment of weakness I consented. This morning a friend of mine said he had heard I had turned lecturer, but he said any attempt of this sort would be a mistake—that the presentation of a technical subject in the form of a lecture just could not be done. Well, I am something of an optimist, although I see even my Committee has deserted me. I will have to take the full responsibility, for I have not tried it out on them.

I have two topics I want to speak on: One connected with rail-joints, and the other on what I term the present variability in railroad track. I shall try to make it simple, but in order not to overrun my time too much I have written it out.

SOME FEATURES OF RAIL-JOINTS

By Arthur N. Talbot

This is to be an informal presentation of two topics—"Some Features of Rail-Joints" and "The Desirability of Reducing to a Minimum the Present Variability Factors in Track". I hesitate to discuss these topics in a talk because it is difficult to discuss technical questions satisfactorily without considerable complex technical detailed analysis requiring more time and more opportunity for explanation and study than are available here to-night and because much of what I have to say appears to me to refer to matters of common knowledge among track engineers. I feel, however, that the various subjects included in this talk are well worth consideration and I hope the views presented will at least stimulate thought on the relation between some of the simple matters presented and the methods of track construction and maintenance. The effort will be made to avoid "high-brow stuff" and to present only the simpler relations that may be grasped at first mention, even at the risk of omitting the data and proofs and limitations necessary for a conclusive argument.

It is obvious that an ideal rail-joint and its supporting substructure would have the same stiffness as has the full rail away from the joint (that is, the track at this point will depress the same as other points on the rail when the load moves along), and will also have adequate strength. Also, the track at the rail-joint should require as little maintenance and renewal as elsewhere. Among many things this last would involve freedom from defects of the rail-joint that are due to flow by reason of the lack of continuity of the steel at the rail ends, and from batter that is due to joint gap or to variation in height of adjacent rail ends (as well as to other sources)—of themselves too large questions to be considered at this time. It is needless to say that the ideal rail-joint is only a dream—we can only hope to approach its good qualities. In the part of my talk that is devoted to rail-joints, I can not take time to do more than touch upon a few of the principles that relate to good joints.

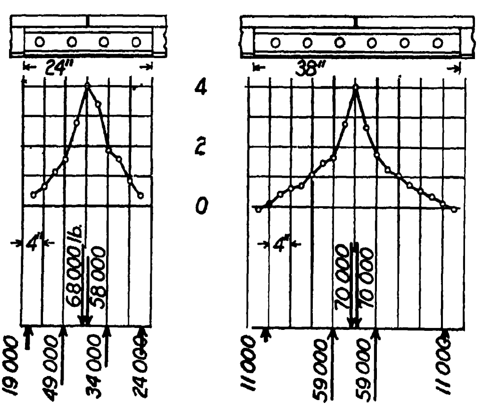


Fig. 1. Moments and Forces in Rail-Joints.

A joint bar has a characteristic distribution of bending moments along its length, regardless of the sectional shape. In Fig. 1 the ordinates represent the value of the bending moment in the two bars at various places along the bar in hundreds of thou-

sands of inch-pounds as developed by a given load. The vertical distance at the middle represents the moment in the bar at mid-length, another ordinate the value out a few inches from the middle, and toward the end of the bar only little or no moment. The pointed, peaked diagram is characteristic of well-fitting bars of all the ordinary types whether short or long. For poorly fitting and loose bars the stress diagram may be less pointed and the stresses be greater towards the ends of the bars, but other considerations show the great desirability of closeness of fit. The action of the joint bar as a beam or girder subject to this positive or downward bending moment may be approximated by considering the application of a downward bearing force under the head of each rail near the rail ends and either one or two reactions upon the lower face of the bar from the base of rail for each half of the length. As here represented there may be two such reaction forces on each half of the bar. The magnitude of these reaction forces are represented by the length of the lines on the diagram. The form of the diagram varies according to fit—this particular diagram for the long bar is more nearly symmetrical than the usual diagram for joint bars, whether short or long. It will be noted that the peaked condition means that the reaction forces applied toward the ends of the bars are relatively small, and that the bearing pressure near the end of the rail and the main reaction force for each half of the bar are close together, in well-fitting bars, say about 4 in. apart for either long or short bars. This indicates that the bearing pressures at the top of the bar are high, since for a given moment the value of the force is inversely proportional to the lever arm. It is found that the better the fit of the bars the larger the main reaction forces and the more marked this peak is for the same bending moment developed in the rail-joint. These large bearing forces may not be objectionable if the material in the bar is hard enough to resist it, as is the case with bars meeting the specifications of the Association. Their presence, however, must be understood and appreciated. This closeness of the main reaction bearings to the rail ends is likely to make the flexibility of the whole rail-joint more nearly the same as that of the rail. With poorer fit the slope of the moment curve is less, the main reaction is farther from the middle of the bar, and is smaller. The lack of fit and the presence of play between rail and bar, however, bring troublesome effects in the way of increased deflection of the joint and the bars do not take their share of the bending moment. There are ways of keeping good fit and yet moving the main reaction farther from the middle, but time will not permit their discussion.

With poor fit the vertical movement between rail head and top of bar at the rail end and between bar and base of rail at the bar end when the load is applied adds to the deflection of the joint without developing proportionate bending resistance when the load comes on, and thus the proper distribution of load on the ties is interfered with. At best the deflection of the joint bars themselves is greater than the full rail—perhaps three or four times as much within the length of the bar for ordinary joints and less for the best forms of joint. Well-fitting joints give a sum of the play or vertical movement between rail and bar at the end and the middle of the joint bar of, say, not more than .005 or .006 in., and this amount of play is not very objectionable. Many joints, however, owing to poor fit, have a play five or even ten times this, and this large movement adds greatly to the deflection of the joint and detracts greatly from uniformity of track surface conditions.

It was brought out in the Fifth Progress Report of the Committee on Stresses in Track that the shape of the joint bar needs consideration. In the angle bar type the full value of the material as a girder is not realized; unless very tightly restrained the neutral axis is well away from the horizontal position ordinarily assumed. The angle bar, however, is a very useful form for rails of, say, 100-lb. per yd. or under, for in these

sizes the fishing height of the rail is too small to permit a strong and stiff symmetrical bar to be designed. For heavier rail, bars of symmetrical form or approaching symmetry have advantages if certain requirements are met. It should be understood that merely cutting off the flange of an angle bar section without re-designing the bar by putting back the cut-away material where it will benefit the section materially may weaken the bar and leave it without the requisite strength and stiffness—the designer should be warned against this.

With the sections of joint bars shown in Fig. 2 are given the ratios of properties of joint bars and rail sections. A and A_0 represent the sectional area of joint bar and rail, respectively; I and I_0 the moments of inertia, and S and S_0 the stresses developed by any given bending moment. The values of I and S used in the ratios given at the left of the sections at the upper middle apply to the angle bar section there shown and take into consideration the restraint which may be found in the track under ordinary conditions.

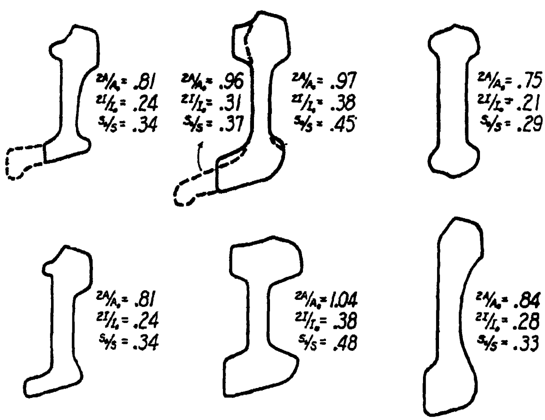


Fig. 2. Shapes of Joint Bars.

In Fig. 2 the bar for 90-lb. rail at upper left shows what cutting off the flange of an angle bar would do—it is still a Z-shape, an undesirable feature and the metal cut away is needed either where it was or at some better location. It is easily seen that there are limitations on the design of a symmetrical section of adequate strength and stiffness for the lighter size of rail.

The bar for 110-lb. rail with cut-off flange at lower left seems very light—the sectional area of two bars is only 80 per cent of that of the rail and the stiffness of the two bars is only one-fourth of that of the rail. It could well be made stronger and stiffer.

The suggested re-design of bar for the 127-lb. Dudley rail shown in the middle top gives 23 per cent more stiffness and 22 per cent more strength than the original section without any increase in area, and a change or two would further improve the design, perhaps increase the stiffness to as much as 40 per cent above that of the original section.

The study section F for 130-lb. R.E. rail found in the report of the Committee (shown at middle bottom) gives a strong, stiff bar with properties close to those of a symmetrical bar. There is room, however, for some strengthening and stiffening of the section. The relatively small fishing height of this rail section as compared with the Dudley section is an obstacle to making a fully satisfactory design.

The D. L. & W. symmetrical bar for 130-lb. R.E. rail shown at upper right is somewhat light but it is giving good service.

The new form of bar for the P.S. 152-lb. rail shown at lower right is of considerable interest. The sectional area of two bars is only 84 per cent of the area of the 152-lb. rail. The stiffness of the two bars seems to be about 28 per cent of that of the rail, and the strength 33 per cent. Attention is called to the very high fishing height. I have not made a study of the properties of this bar with respect to symmetry, but it appears to approach symmetry fairly closely. We shall all be interested to learn how satisfactorily this rail-joint behaves.

Let me add the thought that for rails heavier than 100 lb. the strength of most rail-joints is usually adequate; it is the other properties of the rail-joint that need improvement—decrease the flexibility, increase the stiffness, improve the fit.

Of all the devices and changes in conditions relating to the rail-joint, a decreased spacing at the joint ties may be said to have the greatest influence upon the relief of stresses in joint bars and the avoidance of low joints in well ballasted track. This decreased tie spacing is an effective agency up to the point where the greater stiffness of the track support becomes troublesome or objectionable, especially at the full rail opposite the joint. The increased vertical stiffness of the track with decreased spacing of joint ties is due both to the greater number of ties per inch of rail and, what is much more important, to the greater stiffness of the ballast resistance because of the effect of the greater horizontal pressures developed in the ballast between the more closely spaced ties. The length of the arrows in Fig. 3 are intended to give a conception of the relative bearing loads that may be taken by joint ties and other ties when the former are more closely spaced than the latter, even if the joint is somewhat more flexible than the full rail. This increased vertical stiffness of the track at the joint ties has two effects (1) an increase in the vertical tie reactions (upward pressures) acting on the rail at and near

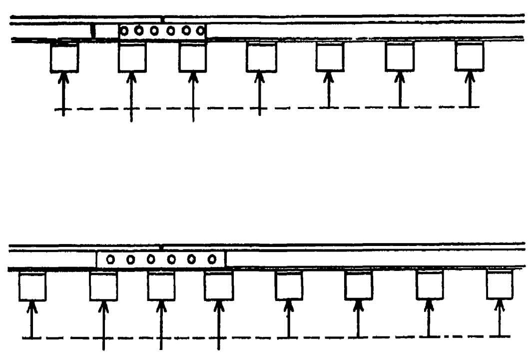


Fig 3. Spacing of Joint Ties.

its ends as compared with what is normally taken per inch of length of rail elsewhere, and (2) because of this change a reduction in the positive bending moment put into the joint bars by reason of the greater concentration of vertical reactions in the neighborhood of the rail-joint. With decreased spacing, then, the bending moment put into the joint bars is lessened and, besides, the deflection at the joint is decreased. It is apparent that by proper spacing of joint ties the somewhat greater flexibility of the rail-joint as com-

pared with the full rail may be overcome and the vertical depression of the track at the joint may be kept comparable to that of the full rail elsewhere.

The extent of the decrease in the tie spacing that will give most satisfactory results can best be learned by experience. Two items need be taken into account in considering the problem of the best spacing—(a) the degree of effectiveness obtainable in tamping the track for the smaller tie spacings used and (b) on the other hand the possibility that the joint ties may be given so much decrease in spacing that hard supports in track will be produced at or opposite the rail-joints and thus be objectionable.

It may be concluded that a proper decrease in the spacing of the joint ties is a most important element in the design of rail-joint in track. There is not time to discuss in detail the range of change in tie spacing which may be used. A spacing of the two or three joint ties 2 or 3 in. less than the tie spacing elsewhere and a smaller decrease in the space to another tie just outside this group may be expected to give satisfactory results with fairly stiff bars. If light bars are used or the bars are poorly fitting the spacing must be even less.

It should be accepted as a principle that so far as the number of tie spacings to be given a decrease in spacing and the amounts of these decreases are concerned, the length of the bars (whether short or long) and the type of the joint support (whether suspended or supported) will not enter into the problem, for it is the rail that is supported by the tie-plate and tie—the bar does not come in contact with the tie-plate—and for any ordinary form of joint bar the same change in stiffness of support will apply to different types. Features of slot spiking or of tie-plate fastening or other accessory matters may lead to preference for one way or another of arranging the joint ties, but generally even these differences may be arranged independently of whether the bars are short or long or whether the joint is suspended or supported. The notion that the joint is supported just in the length of the bar should be forgotten.

THE DESIRABILITY OF REDUCING TO A MINIMUM THE PRESENT VARIABILITY FACTORS IN TRACK

By Arthur N. Talbot

In the tests of track made by the Committee from time to time measurements have been made of stresses in rail. The purpose of these measurements was not alone to learn how large the rail stresses are; an important purpose has been to obtain data from which a study of track conditions and track properties may be made—to learn where there are defects in track, to suggest improvements that may be made—to find under what conditions good track qualities are obtained and when poorer results are found—in fact, to find the characteristics of the action of track of different kinds. In the track tests made from time to time I have frequently been struck with the variability of most track from point to point along a given stretch under not very widely varying conditions. I shall be speaking of what would usually be called good track—heavy, high-grade track, not run-down track or track that is considered to be in poor condition.

In Fig. 4 are shown the stresses in the base of 130-lb. rail, measured at every other tie and given in terms of the average stress all along the two rails as unity. The tie spacing averaged about 21 in. The ballast was hard, broken stone of excellent quality to a depth of perhaps 20 in. or more below the ties, and the bed would be called a very stiff bed. New rail and new tie-plates had been laid six months before the tests and a moderate amount of track surfacing had been done one or two months before, and the traffic over it was of the heaviest. Measurement of stresses at every tie would have been

preferable, to save time the stresses in base of rail were measured at every other tie, and the locations were chosen at random along a given stretch of track. Two of the several locations are shown in the figure. The ordinates of the points of the two light lines give the stresses at the two edges of base of rail, measured in terms of average stress along the track as unity, the full line representing the stress at the outer edge of the rail (on outside of track) and the dotted line the stress at the inner edge. Note the marked variation in stress and the rapid change from point to point for both the north rail and the south rail. It will be seen that the greater stress is sometimes at one edge and sometimes at the other, quickly changing from one side to the other and ranging from nothing on one edge of the base to double the average stress at the other edge, in one case even to three times the average stress. These differences in stress at the two edges of the base of rail and the changes in position of maximum stress indicate a constantly changing lateral bending, sometimes one way and sometimes the other, and also

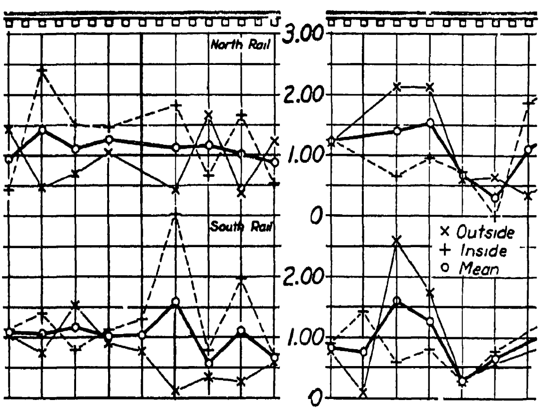


Fig. 4. Variability in Rail Stresses for the Same Wheel Loads.

a marked twisting in the rail. It should be noted that these measurements were made by moving the load from point to point along the track and always measuring stress in rail directly under the rear wheel, and the movement of the load was such that the bearing pressure of the wheel on the rail was practically alike in all cases and the wheels were at relatively the same place on the top of the rail, applying almost identical vertical and lateral loads at every spot. Remember, it is not a question whether the rail is strong enough to take these twisting and lateral bending stresses but rather that the tests show extreme variability in the action of the track and a crazy distribution of the forces along the track, and the question arises as to what the cause of this variability is and what will be its effect on the track (the ties and tie-plates and ballast bed, as well as the rail) and on the cost of maintenance.

The heavy line of the diagrams in Fig. 4 shows the average or mean stress in base of rail and may be considered as representative of the vertical bending moment developed in the rail from point to point. It will be seen that these mean stresses vary greatly from point to point along the track, being as much as 1.6 times the average stress along the track and at another place not far away only three-tenths of the average stress. That is, the mean stress in base of rail as measured on this short stretch of track varied from .3 of the average stress along the track to 1.60 times the average stress, and this with the same load applied in the same way.

Without attempting to go into a careful study of all of this variability let me ask you to try to follow some of the further slides which may indicate the direction or source of the variation.

In this same track pull-up and push-down tests were made on some of the same stretches. In these tests cars are not used to load the track. In the pull-up test a bar is placed under the tie at its end and using this as a lever the tie is lifted by man-power until the tie-plate comes in contact with the base of the rail and levels are taken to determine the amount of this lift, at a point on the tie at or near the rail; the result measures the vertical play between rail and tie which is overcome when a wheel load is applied. Similarly, in the push-down test a bar is placed in such way as to push the tie downward to reach the general position of its ballast bed, care being taken to pull the spikes slightly in the few cases where the rail may be holding the tie up; the result measures in a way the play between tie and its ballast bed. Fig. 5 shows samples of these tests. This figure looks something like a line profile in a rocky and mountainous country. The ordinates in the diagram down to the points of the fine line represent the play between the rail and the tie as found by the pull-up test. The lines connecting these points are for convenience in following the points for the successive ties. You will

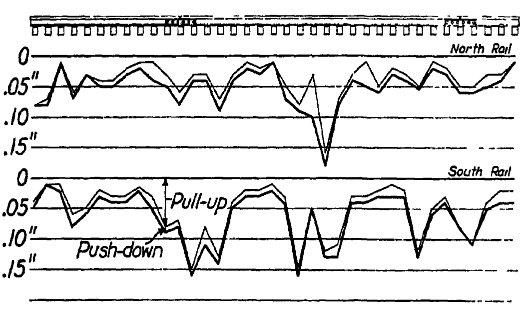


Fig. 5. Pull-up and Push-down Tests. Play Between Rail and Tie Bed.

note a considerable range in this play, say between 0 and .15 in., and there was even one of .25 in. at a location not shown on the slide. The distance between the fine line and the heavy line represents the play between the tie and its ballast bed; this is a smaller amount, say from 0 to .03 in. The distance from the base line to the points on the heavy line represents the sum of the pull-up and push-down measurements, the total play between rail and ballast bed—the distance the rail must go down before the tie will take load; that is, before the tie will give support to the rail. The values given in this figure range from 0 to .18 in. Note that it is not so much the amount the rail must depress before it will receive tie support; it is rather the differences between the play at one tie and its neighbor, between the play of a group of two or more ties and another group of two or more ties near at hand within the length of a wheel truck or of two wheel trucks of adjoining coupled cars. It will be seen that there will be considerable variation in play for groups of ties as the car wheels are supported by one group or the next or partly by each of two groups as the cars move along. You will realize that these conditions produce very uneven stiffness in tie support. Adjacent ties will carry loads which vary markedly in amount—some no load at all and some double their share or even more. The groups of these tie reactions, by their wide variation, will give far

different loading effects upon the rail and therefore a wide range in the bending moment developed and in the resulting stress in rail from point to point along the track.

In Fig. 6 are examples of variation in individual tie loads based on these tests. The pull-up and push-down test values have been used to estimate the load taken by individual ties. These loads may be estimated by considering that a group of ties between and just outside of the wheels of the truck of a loaded freight car are depressed the same amount (and this is closely true with 130-lb. rail) and that the loads carried by individual ties are proportional to the net depression of the tie and that for this purpose

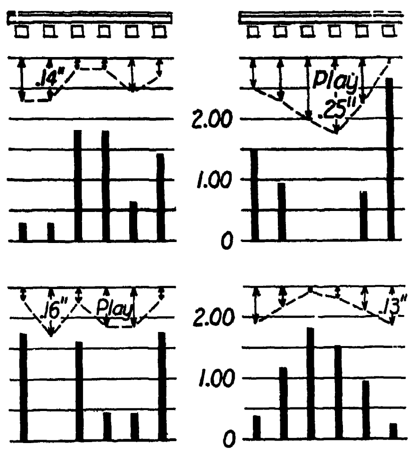


Fig. 6. Diagram of Possible Variations in Tie Loads.

the reaction of the ties away from this group may be neglected (their support could easily be taken into account), the six ties carrying the full load—at least this assumption is nearly enough correct for illustrative purposes. For this track and the medium load used in the tests (15,000 lb. per wheel) the average net depression for each of the six ties would be .07 in.—very stiff track. Four locations are shown on the slide—other spots would give still different values, though perhaps these are as variable as any on the stretch of 700 ft. on which pull-up and push-down tests were made. The ordinates of the upper diagram in each group give the play between base of rail and tie ballast-bed (sum of pull-up and push-down tests)—here is a play of .03 in., there one of .14 in., and there one of .25 in., a large one, but to be found occasionally in most track. Note that the sample locations shown on the slide have a variety of groupings. Of course, the tie will not take load until the rail has been depressed an amount equal to this play; beyond that it is assumed that the load taken by the tie is proportional to the further depression, the net depression. On this basis the loads taken by the individual ties are calculated to be the values shown by the heavy vertical lines—all measured in terms of the average load which one tie should carry under normal assumptions as unity. In the group at the upper left hand corner the end tie carries 25 per cent of its share of load—there 180 per cent of its share, 1.8 times its share. In this group of ties at the right, the range is from 0 at the two middle ties to 2.6 times its share. In the group below, the middle ties carry the bulk of the load. These individual loads or reactions affect the value of the bending moments developed in the rail. It is evident that as the car is moved along the track the bending moments in the rail and also the stresses will vary

greatly from point to point—in one place the moment will be high, when the wheel is in a given position, in another low, etc. With such variable supports, such diverse tie loads (tie reactions), the moments and stresses and tie loads from point to point, as the car moves along the track, must vary widely, and the rail, tie, and ballast bed will be punished accordingly. The rail may be able to stand the variable stresses without trouble (unless other conditions are unfavorable), but the substructure should not be compelled to bear the unnecessary burdens.

Now let us see what may cause much of the lateral twisting and bending in the rail. As I have examined track, I have found many, many tie-plates that do not fit the tie and their top bearing face is not in the same plane with the base of rail. The planes of these bearing faces on adjacent ties may be off in opposite directions, and the bearing at the rail at one end of the tie may disagree with the bearing at the other end. The adzing for the tie-plate is not regular and the plate may rock. A gauge the thickness of a sheet of paper may be placed under the rail or under the tie-plate over parts of the bearing area when the rail is loaded—even the edge of a shovel—sometimes the thickness of a knife blade, either above or below the tie-plate. I am not speaking of poor track; and the heavier the rail and the stiffer the ballast bed the greater the disturbing effect. This all means that the position of the resultant of the upward reaction of the tie and tie-plate at one tie does not agree with the center of pressure of the next tie, and both may not be in the same plane with the wheel loads, and there is a resulting twist produced by the forces, or in other ways a lateral bending is produced in the rail. On the slide (Fig. 7) I have tried to picture conditions of bearings that produce eccentric loading, torsional effects, twisting of rail from tie to tie, lateral bending of rail. It is the upward force we are considering—not downward as shown by the slide. In the upper left hand corner the position of bearing pressures may be such as to produce neither twisting nor lateral bending. In the one below the bearing is mainly over the shaded area and the center of gravity of the reaction may be central on the rail but not

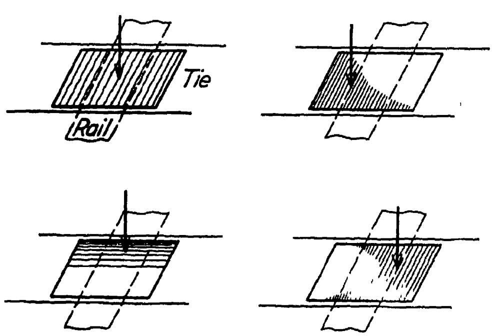


Fig. 7. Diagram Indicating Variations in Position of Centroids of Tie-Plate Pressures.

central on the tie. In the one at the upper right the centroid of bearing is at one side, and the tendency is to twist the rail in the opposite direction, or perhaps to bend it, laterally one way or another. The one at lower right gives a twist in the opposite direction, and these two diverse conditions may be found in adjacent ties or be distributed in all sorts of groups. Some combinations may concentrate vertical pressures at one edge of the base of rail and others will place it at the opposite edge. And with the stiff rails

which do not distort much under twisting forces, the full effect is transmitted to ties and ballast. Doubtless all of you have observed the unevenness of bearing referred to—perhaps you may not have appreciated fully the troublesome effects of defective adzing and imperfect bearings. One remedy, it may be said with confidence, lies in machine preadzing and preboring of the ties and the application of the tie-plates in the shop, where skillful and workmanlike methods may be used to ensure accurate fit and identical planes.

For Fig. 8 refer to Fig. 4, which has already been shown. I am showing it again to bring to your mind again the variations in stresses in the rail which have been found in what is called high-grade track (and which are common conditions in the majority of such track). The variations in stresses at the two edges of the base of rail (shown by the light lines) I think you will agree are indicative of lateral bending and twisting of the rail, even when the wheel loads are applied centrally. Let me repeat: A principal source for this variability lies in the unevenness of bearing between rail and tie. The rail may not bear evenly on the tie-plate, or the tie-plate on the tie, or both. The other variability referred to, that of the mean stress in base of rail (shown by the heavy line) is due to unevenness of tie support from point to point, as shown by measured variations in the play between rail and tie and between tie and ballast illustrated in the previous slide. It should be agreed that for high-grade track the effort should be made in its maintenance to reduce these variable features to the smallest amount practicable.

The diagrams in Fig. 9 give data obtained on another track—also a high-grade track. The rail is lighter—110-lb. The track is well and deeply ballasted. The stretch shown on the left half of the diagram has hard limestone, well compacted, and the track substructure is very stiff—the stiffest track we have tested. The stretch on the right half

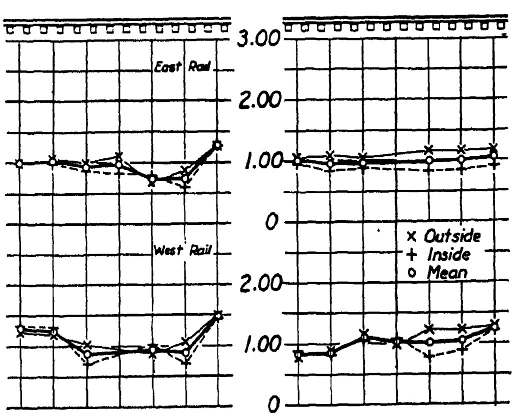


Fig. 9. Stresses in Rail with Ties Preadzed and Prebored.

of the diagram has flint gravel ballast and is less stiff, though this track is above average stiffness. As in the other slide, the loaded car was moved from point to point along the rail and the stress was read at the two edges of the base of rail immediately under the rear wheel of the heavily loaded freight car (26,500 lb. per wheel) at every second tie space. Note the stresses in the two edges of the base of rail (shown by the light lines). There is little crossing of these two lines—some lateral bending but generally in one direction—hardly any twisting. The mean stress in base of rail (shown by the heavy line) is also fairly uniform along the stretch. It should be said that spots were found

elsewhere having the individual tie loads more variable, and showing a greater diversity in bending moment in rail from point to point, though the twisting and lateral bending found were small, and there was more variation in play between rail and tie bed. I said this rail is lighter than that in the last slide. That is not the source of the improvement in uniformity. One great difference between this track and that of the last slide, and the one which in my opinion most largely results in the small amount of variability in stress in the two edges of the base of rail is this, the ties in this track were preadzed and prebored and the tie-plates applied in the shop in a workmanlike manner with tie-plates held firmly in the right place by screw spikes. In other track having the tie-plates applied in the same way, tested some years ago, this same uniformity of action was apparent, but the tests were not made comprehensively enough to bring out so fully the evenness of stress relations. Another feature of the track shown here that contributes to the uniformity is the presence of a compressed wood shim immediately under the rail, though I am unable to say to what extent the shim contributes to this particular feature of track action. This track, of course, is GEO construction on which some test work was done to learn something of the characteristics of this type of track, but in this matter of preadzing and preboring the construction follows in several ways practice in use in this country for several years and which was tested by us some years ago.

Fig. 10. Variability in Individual Tie Loads for Light and Stiff Substructure.

	Light Substructure	Stiff Substructure
Average net depression for 25,000 lb. wheel load	.35 in.	.07 in.
Possible range of tie play	0 to .07 in.	0 to .07 in.
Range in individual tie load	90 to 110%	50 to 150%
Greater range of tie play	0 to .14 in.	0 to .14 in.
Range in individual tie load	80 to 120%	0 to 200%

Note: Alternate ties are considered to have the full play and the other half to have no play.

Let me close this little discussion of track properties by further calling attention to the importance of attending to details in items other than the adoption of heavy rail and deep ballast for stiff, heavy high-grade track for heavy traffic. The stiffer rail spreads the load over more ties to some extent, but not very much farther for a group of wheels like drivers or car trucks. The stiffer ballast bed is now in general use. It follows that with this stiffer ballast bed the net depression of rail under heavy loads is much smaller than with the lighter track substructure formerly in use. Some of the first track tested by the Committee years ago gave a net depression under heavy loads of say .35 in. Some of the later tests with much stiffer substructure give only .07 in. for the same loads, one fifth as much. Further, the variability of the play between rail and tie in much track has not changed greatly. Let us see what effect stiffness of substructure has on variability of stresses if the same play between rail and tie ballast bed is permitted in the two types of track, that with light substructure and that with stiff. The assumptions to be used are not accurate and would not be found on any track, but the comparison will give an idea of what does exist. The resulting variability in individual tie loads, for both light and stiff substructure, is recorded in Fig. 10. Consider first that for both types of track the play at alternate ties is .07 in. and that the free

rail rests only on every other tie, and that under load the average net depression of all the ties is .35 in. for the light substructure and .07 in. for the stiff substructure, and that the first tie (as we count along the track) takes load from the start and the second only after the rail has depressed .07 in., and so on. Then, on the assumption that the net tie depression is proportional to the load carried, for the light substructure the load on consecutive ties would be 90 per cent on one tie and 110 per cent on the next tie, and for the stiff substructure 50 per cent on one tie and 150 per cent on the next. Again, if the play at alternate ties is .14 in., the resulting loads on alternate ties would be 80 per cent and 120 per cent of the normal tie load for the light substructure and 0 and 200 per cent for the stiff substructure, a great divergence. Although the distributions of loads shown on the slide are calculated values, they tell how variability may happen. And bear in mind that these examples are not the worst cases that are to be found.

The tests of other years have also shown the same great variability in stresses from point to point along tracks and on heavy rail and stiff ballast, and the sources have been traced to variability in tie height and bedding and to general unevenness in rail support. It is evident that greater stiffness of rail and greater stiffness of ballast bed, without correspondingly improved track surfacing conditions, contribute to the variability in moments and stresses and to variability in the distribution of tie and ballast loads. All observations emphasize the need of great care in the substructure of stiff track (track having heavy rails and stiff ballast and tie structure). The things referred to may seem small, but they may be expected to have an important effect on the usefulness of very large expenditures.

One of the great needs is a method of tamping track uniformly, and further, a method of knowing when the tamping has been done uniformly. I have great admiration for the eye of the track foreman who brings the line and surface of the rail so accurately to position, but unfortunately he can not see under the rail, or under the tie-plate, or under the tie or into the ballast, and can not gage the stiffness of the ballast as it varies from tie to tie. The idea that the track will be settled and pressed down into greater uniformity by the action of traffic may do for light, loose material, but with stiff ballast the hard spots become harder and the spots with looser material go down. Perfection is not possible, but the man who will devise a means for judging and regulating toward uniformity the stiffness of this substructure will do a great service for track maintenance. And the heavier the rail and the stiffer the substructure the greater the gain will be.

These statements are not to be taken in any way as criticisms of heavy rail, for the increase in stiffness of the substructure of track in recent years is a much more important factor. They are intended to mean that with heavier rail and stiffer ballast there should go a correspondingly greater attention to the quality of the substructure, to the nature and relative position of the bearing surfaces between rail and tie-plate and tie and to obtaining a smaller variability in the division of load among ties and a better distribution of the pressures between rail and tie. With this may well be given more careful consideration to the adequacy of the ballast shoulders and to the length and uniformity of ties and tie spacing and other elements affecting the track substructure. And do not forget that the bearings and position of the tie-plate on the tie and the nature of the tie-plate fastenings should have careful attention. To all this, in my opinion, the track engineer should give further intensive consideration.

The President:—I am sure that with me each of you, as you have shown by your applause, wants to express real appreciation to Professor Talbot for his interesting and instructive lecture, and will agree that whoever told him this morning that he could not make a success of it was "all wet" (Applause).

DISCUSSION ON ECONOMICS OF RAILWAY OPERATION

(For Report, see pp. 193-205)

Mr. J. E. Teal (Chesapeake & Ohio):—Before presenting the report of Committee XXI—Economics of Railway Operation, I wish to say that your Committee has suffered the loss of one of its most esteemed members, H. T. Porter, retired Chief Engineer of the Bessemer & Lake Erie Railroad. Mr. Porter was a member of this Committee since the year 1923, during which time he took an active interest in the work of the Committee, never missing the Committee meetings unless prevented by important work or ill health. His advice in connection with developing the problems of this Committee was always helpful. Mr. Porter died on January 11, 1932, and his death will be greatly felt.

Your Committee also suffered the loss of a highly respected member, Professor Howard E. Boardman, Dudley Professor of Railway Engineering, Yale University, who died on February 28, 1932. Professor Boardman had just recently been appointed to the Committee, and by his death the Committee feels that it is losing the services of a very valuable member.

The report of Committee XXI—Economics of Railway Operation, will be found in Bulletin 341, on pages 193 to 205 inclusive.

Progress report covering assignment (1), Revision of Manual, including Revision of the Method for the Determination of Proper Allowances for Maintenance of Way Expenses due to Increased Use and Increased Investment, will be found on page 194, Appendix A. Mr. J. F. Pringle, Chairman of the Sub-Committee, is unable to be present.

The Committee has particularly been giving consideration to various maintenance of way and structure primary accounts, and it has concluded that on account of changed conditions covering maintenance practices, the use factors as shown on pages 1406, 1430 and 1431 of the 1929 Manual may possibly be affected. The Committee is handling this question with the view of reaching conclusions as soon as practicable.

Report covering assignment (2), Methods for Obtaining a More Intensive Use of Existing Railway Facilities, with Particular Reference to Securing Increased Carrying Capacity, will be found on page 195, Appendix B.

This report is divided into two parts. Part I is material for the Manual, being the conclusions drawn from last year's report, which was the subject of considerable discussion on the convention floor.

In addition to brief conclusions, convenient references to reports that have been presented by this Committee within recent years are indicated. I will read Part I:

"Studies have been undertaken and published in the Proceedings to test out the theory of train-hour diagrams and obtain experimental knowledge that will serve to extend the scope of the method in connection with the investigation of factors affecting freight train operation. They indicate that comparative freight train performance charts provide a simple and accurate method for showing actual results obtained by various methods of operation or changes in facilities. From these studies the following conclusions have been drawn:

"A. (1) It has been found that freight train operations can be represented by a mathematical law (A.R.E.A. Proceedings, Vol. 32, page 641).

"(2) The application of this law to different sets of observations makes it possible to compare several months' operation of a given division on a more equal basis. Likewise, operations of different divisions which are more or less similar can be compared on more nearly the same basis (A.R.E.A. Proceedings, Vol. 32, page 641).

"(3) By such comparisons the effect of extreme weather conditions, greater facilities, motive power, different commodities and supervisory methods on the average time on the road can be more accurately determined (A.R.E.A. Proceedings, Vol. 32, page 641).

"B. (1) Increased supervision, consisting of scientific study and thoughtful effort, will increase the capacity of a railway (A.R.E.A. Proceedings, Vol. 26, page 878. Vol. 32, page 641).

"(2) Increasing capacity of locomotives results in an increase in the capacity of the railway (A.R.E.A. Proceedings, Vol. 26, page 878. Vol. 32, page 641).

"(3) Double tracking will increase the capacity of a railway—the increase in capacity being proportional to the amount of second track. Careful study should be given to the practicability of increasing capacity of single track and obtaining more intensive use of same, either by increased supervision and study of operations, signals, etc., before constructing double track (A.R.E.A. Proceedings, Vol. 24, page 1046; Vol. 27, page 746; and Vol. 30, page 752; Vol. 32, page 641).

"(4) Installation of automatic signals on a single track railway will increase the capacity of the road—this increase varying with the length of the division on which installed and with the number of passenger trains operated (A.R.E.A. Proceedings, Vol. 27, page 739; Vol. 31, page 1003; Vol. 32, page 641).

"(5) Installation of centralized traffic control system on a single track railway will increase the capacity of the road. This method of increasing capacity should be considered when the volume of traffic justifies or when other conditions necessitate (A.R.E.A. Proceedings, Vol. 31, page 1010; Vol. 32, page 641).

"(6) Use of large engine tanks or water cars will increase the capacity of the railway by eliminating delays and permitting greater movement of traffic over the same district (A.R.E.A. Proceedings, Vol. 29, page 193; Vol. 30, page 754; Vol. 31, page 1010)."

The Committee recommends that the above conclusions, beginning with the first paragraph under the heading Part I, be approved for printing in the Manual, and I so move.

The President:—Is there any discussion?

(The motion was put to vote and carried.)

Chairman J. E. Teal:—In the absence of Mr. M. F. Mannion, Chairman of the Sub-Committee, I will present Part II of this report, which is found on page 196.

In former years, this Committee has been working on problems dealing with increasing business which required increased capacity. This year the reverse is true. With decreased business, we find instances where the continued operation of double-track lines seems to be uneconomical. The Committee submits a report on the effect of removing 25 miles of second track on a 62-mile section of road where the traffic has been greatly reduced.

Information indicates that the previous heaviest traffic occurred about 1911 when from 50 to 60 trains were operated over this section daily. The heaviest traffic of recent years was in 1920 when 24 freight trains and 6 passenger trains were operated daily. In general, about the same class of power has been used throughout the past ten years.

Trains are operated on the present line by timetable, train order and manual block. Maximum speed, 50 miles per hour for passenger train, and 30 miles per hour for freight trains.

Factors to be considered in converting double track to single track are enumerated on page 198, and embrace:

1. Present and proposed track plans.
2. Expenditures necessary in connection with the track changes.
3. Effect on track, bridge and other maintenance; taxes; train operation; cost of transportation and track capacity.
4. Method of directing train movements.
5. Annual savings and return on expenditures.

Fig. 1 on page 203 shows the profile and present and proposed track plan of the line. The proposed plan involves removing and/or changing a number of turnouts, crossovers, industrial spurs, manual block and flasher signals, and water facilities, in addition to retiring a total of about 25 miles of track.

The table at the top of page 199 shows the accounting incident to making these changes, being a credit of $566,000 to Capital, debit of $5,400 to Operating Expenses, and a debit of $499,100 to Profit and Loss, leaving a net credit of $61,500. The cash outlay is estimated at $52,820, of which $20,670 is Capital, $4,665 Operating Expense, and $27,485 Profit and Loss.

The decreased cost of maintenance, due to the retiral of 25 miles of track, is shown in the table at the bottom of page 199, being $27,880, or $1130 per mile.

In addition to this, with the retiral of this amount of property, a decrease in taxes may be expected, which is estimated at $3000 for the line.

In this particular case, the traffic has become so light that the estimated increased cost of train operation per annum is only $784.

In addition to the credit of $61,500 for salvage of material, the net annual saving is estimated at $30,096 as shown on page 201.

Of the $52,820 cash outlay required to make the change from double to single track, $27,485 is incident to cost of salvage and necessary changes resulting from the abandonment of the second track. This thought is offered for consideration because, at this time of reduced earnings, a railroad having such a problem may not be ready to assume the retirement charges incident to the actual removal of the abandoned second track. Summary is shown on page 202, embracing:

1. Expenditures and credits for track and other changes.
2. Decreased cost of maintenance and taxes, and effect on cost of operation.
3. Return on investment, being 57 per cent on a cash requirement of $52,820.

The conclusion is: "Where the volume and distribution of traffic on a double track line has decreased enough to warrant a reduction in facilities, the converting of double track into single track should be considered."

Your Committee recommends that this report be accepted as information.

The President:—Is there any discussion, or any suggestions? If not, it will be so handled.

Chairman J. E. Teal:—Before passing to the next report, I wish to make one correction in connection with Appendix B. On page 198, under item 2 (b), strike out the words "Increased Traffic".

Progress report covering assignment (3), Methods or Formulas for the Solution of Special Problems Relating to More Economical and Efficient Railway Operation, will be found on page 204, Appendix C.

This Sub-Committee has been giving attention to a preliminary study of the problems of operation as affected by curvature and rise and fall. In addition to the memorandum as printed, I might say that in pursuing its investigations, the Committee has found that in the case of certain items no actual data exists on which to base conclusions.

This is particularly true in regard to the possible increase in tonnage due to the reduction in friction as a result of curve greasing. To secure the necessary data by actual physical tests will require considerable use of the dynamometer car, which we hope to have at some future date.

The Committee wishes to offer this as information.

The President:—If there is no comment, it will be so received.

Chairman J. E. Teal:—Progress report covering assignment (4), Most Economical Makeup of Track to Carry Various Traffic Densities, will be found on page 204, Appendix D. Mr. J. M. Farrin is Chairman of the Sub-Committee, and will make a few remarks concerning the progress of the work that has been done.

Mr. J. M. Farrin (Illinois Central):—Considerable work has been done during the past year by Sub-Committees, and the data collected has been studied and methods worked out for the comparison of the effect of each part of the track structure on the track stiffness as a whole. Track stiffness has been taken as a measure of track efficiency, and by making comparison of costs, under varying track stiffness factors and traffic, a relation can be established that will indicate the most economical track make-up under any traffic condition. It is hoped that the study will be completed this coming year and complete report submitted at the next year's annual meeting.

It is therefore recommended that the subject be reassigned for another year.

The President:—If there are no comments or suggestions, it will be so received.

Chairman J. E. Teal:—There is no report covering assignment (5), Methods for Determining Most Economical Train Length, considering all factors entering into transportation costs. The Chairman of the Sub-Committee has been accumulating information on this subject. He is expecting to have material of value for the preparation of a report next year.

The President:—Any comments? The report will be so received.

Chairman J. E. Teal:—Progress report covering assignment (6), The Effect of Traffic Density on Operating Expenses, will be found on page 205, Appendix E. Mr. S. W. Fairweather, Chairman of the Sub-Committee, is unable to be present.

This Committee has been making an analysis of statistical data applicable to Class I roads of the United States in connection with the development of this subject. The Committee is of the opinion that certain broad and determinable factors underlie the fluctuations of railway operating expenses, which principles have a casual relation to traffic density. Up to the present time the work of the Committee has not developed to the point where conclusions may be formulated that can be supported. This is presented as information.

The President:—Are there any suggestions, comments, or requests? It will be so received.

Mr. Teal, we want to thank you, on behalf of the Association, not only for this report but all the reports this Committee has been making and express to you the appreciation of the whole organization for the benefit that is really derived from these studies (Applause).

DISCUSSION ON ECONOMICS OF RAILWAY LABOR

(For Report, see pp. 371–403)

Mr. F. M. Thomson (Missouri-Kansas-Texas Lines):—Report of Committee XXII—Economics of Railway Labor. We have no Revision of Manual recommended for this year.

Subject (2), Analysis of operations of railways that have made marked progress in reduction of labor required in maintenance of way work. Mr. J. A. Parant, Chairman of the Sub-Committee, will offer this report.

Mr. J. A. Parant (Boston & Maine Railroad):—The first property selected by the Sub-Committee under its assignment, as being one of the country's outstanding railroads in the reduction in man-hours for maintenance of way work, was the Lehigh Valley.

In analyzing those operations of the Lehigh Valley Railroad which have reduced the labor hours for maintenance of way work, your Committee has attempted to gather all the information that is available regarding the changes in standards and methods which, to a general extent, were instrumental in effecting the results over a period of years.

It is recognized that there are other elements and methods which no doubt have to some extent also influenced the results on this railroad. It is the feeling, however, that more definite information as to the effect these other rcognized operations have in reducing man-hours will be acquired by continuing the analysis on other railways.

The Committee has endeavored throughout to allocate to the various maintenance operations the savings in man-hours which are summarized on page 379, as in the case of cross-ties, separating as between treatment and reduced mechanical wear; the savings in labor hours of patrolling and other work accomplished through the use of heavier rail. The effect on the man-hours by the use of specialized extra crews has also been considered. Of course, it was not possible to break-down all of the savings in man-hours as between what is termed as the test period and the year under consideration, namely 1929, the year selected as more representative of normal maintenance.

It might be stated that the man-hours in 1930 and 1931 were substantially lower. However, the Committee was able to directly account for all but approximately one million of the difference in the man-hours between the two periods.

Other elements which in themselves have the effect of explaining away this part of the difference in man hours are shown on page 380.

This report is offered as information.

The President:—Gentlemen, this is certainly a very interesting report and I wonder if there are not some questions you would like to ask Mr. Parant before passing to the next subject.

Mr. G. J. Ray (Delaware, Lackawanna & Western):—I note that on page 374 it is shown that the average tie renewals for the test period was 294. That seems pretty high for that section of the country. I am wondering whether you made an attempt to check the preceding years as to that average tie renewal. I remember that for the roads in the Eastern region, during Federal control, the average tie renewals per annum for the test period, covering those roads that had uniformly placed their ties during preceding years, ran from 240 to 255. As I remember, I think the New York Central was 253 per mile, and our own road was about 246. I am just wondering whether the Lehigh Valley average for this period was not a little high. That will, of course, make quite a little difference in your savings.

Mr. J. A. Parant:—The cross-tie renewals were based on the average of the so-called test period. At that time the percentage of treated ties in track was relatively small for the reason that the Lehigh Valley did not start using treated ties until 1911 and in the early years the annual renewals were not 100 per cent treated.

Therefore, only approximately 24 or 25 per cent of the ties in track were treated at the time of the test period and this would reflect in making the renewals relatively high. The renewals shown are based on the actual records of the railroad.

Mr. G. J. Ray:—I want to say this is a very fine report, and the Committee deserves a lot of credit for working it up. It is well worth studying. They have certainly found a lot of ways in which money can be saved. It is perfectly amazing the amount of money which can be saved by properly determining what things should be done in order to take care of future expenses.

There is no question at all but that the Lehigh Valley has a fine railroad, and their track is good. The very fact that they could make such a saving as this, and at the same time have today as good track as they have, is a good example of what others might look forward to.

The President:—Are there any other comments, gentlemen? Mr. Parant, the report will be so received.

Chairman F. M. Thomson:—Subject (3), Effects of recent developments in maintenance of way practices of gang organization (such as use of heavier rail, treated ties, and labor-saving devices, which make practicable small section forces, and conducting the major part of maintenance work with extra gangs. Mr. F. S. Schwinn was unable to be with us today. I am asking Mr. J. F. Dobson, a member of the Sub-Committee, to present his report for him.

Mr. J. F. Dobson (Baltimore & Ohio):—A résumé of what has been accomplished on several railroads in this connection is given on pages 385 to 389 inclusive, under Appendix C. From this study, the following are the conclusions made:

"(1) Recent developments in maintenance of way practices such as the use of improved materials and labor-saving devices have reduced the amount of track labor required for adequate maintenance.

"(2) These developments in maintenance of way practices permit transferring the heavier routine maintenance work from section gangs to specialized gangs equipped with modern labor-saving machinery with large resulting economies."

I recommend that this report be received as information, and I move the conclusions be adopted for printing in the Manual.

The President:—Gentlemen, you have heard the motion, which has been seconded. Is there any discussion?

(The motion was put to vote and carried.)

Chairman F. M. Thomson:—Subject (4), Annual track inspection and prize awards. Mr. E. T. Howson, the Chairman, will present the report for the Sub-Committee.

Mr. E. T. Howson (Railway Age):—The Committee was instructed to investigate and report on the merit of annual maintenance inspections, including prize awards, the use of track recording cars and machines and the best methods of utilizing records secured from such inspections. This report appears on pages 390 to 397 inclusive of Bulletin 343.

The Committee finds that numerous roads do not now and have not made inspections of the character outlined. It finds, also, that other roads favor the practice, believing that there are definite advantages to the maintenance forces and benefits to the properties, but that for reasons peculiar to their roads, financial or otherwise, they have not installed the plan. There are still other roads that have at times in the past conducted inspections but have since abandoned them. There is a fourth group of roads that have conducted and still do conduct annual inspections. The Committee canvassed those roads which now follow or have followed extensively the practice of conducting inspections and outlines the manner in which those inspections have been conducted in its report, on pages 391 to 395.

Observation of the experiences of those roads which have conducted inspections confirms the opinion that definite advantages result from setting up healthy competition in any body of men. Various means have been developed, including visual inspection and the use of track recording devices and other means for rating the various sections, sub-divisions and divisions.

The Committee has boiled down its observations in conclusions which are presented on page 397 and which it recommends for adoption and inclusion in the Manual. Those conclusions are as follows:

"1. Properly directed, competition, stimulated by a material reward for excellence, will increase the interest and activities of the maintenance of way forces.

"2. A well-devised plan for an annual inspection with awards provides a desirable means whereby a definite spirit of rivalry can be aroused and maintained throughout the working season.

"3. The participants should be assured that the competition is being conducted fairly and that other competitors are not being afforded advantages which are not also

available to them. As a means to this end, the mileage should be equated and a standard man-hour allotment per equated mile should be made. This standard should then be modified to correspond with the traffic density over any section or subdivision. The final ratings should then take into consideration any excess or deficiency in the number of man-hours actually employed, as compared with the standard allotment as modified.

"4. The use of track recording machines to provide comparable records of the variations in line and surface, gage and cross level, is recommended.

"5. The records made by these machines have a high value if made at sufficiently frequent intervals and used for the purpose of directing the work of supervisors and foremen, and of indicating to them the points to which they should give preferred attention."

Mr. President, I move the adoption of these conculsions for publication in the Manual.

The President:—Gentlemen, you have heard the motion, which has been seconded. The matter is open for discussion.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—It appears to me that the conclusions found by this Sub-Committee are somewhat contradictory to the conclusions found by the Sub-Committee which just preceded them. Perhaps they can get by on the theory that the conditions do not apply in the same place. However, I wonder if this Committee investigated the experiences of the roads that have tried the prize system and have abandoned it and, if so, what reasons they had for abandoning that system.

Mr. E. T. Howson:—With reference to the first comment of Mr. Baldridge, I confess that I do not see where the conclusions of the two Sub-Committees are in conflict. They are dealing with entirely different subjects. Each refers to the material immediately preceding in the report of that Sub-Committee.

So far as the reasons for abandoning the annual inspections are concerned, they are covered in part in the report. There have been various reasons for abandonment. One or two have been abandoned in the last year because of the fact that they are commonly made by special trains involving some expense. There has also been a feeling in some cases that it is difficult, with the more or less incomplete methods of measurement in vogue on some roads, to make the awards fairly. Other roads have felt that this is not an insuperable objection and have endeavored to revise their plans to overcome that.

The roads which are reported on pages 391 to 395 inclusive are, in the main, roads which have followed the practice of making inspections for years and are thoroughly sold on the advantages, as they advised the Committee; and report further the objections, if any, have been small compared with the advantages gained in increased output of work and increased interest that results from rivalry.

Mr. C. W. Baldridge:—The reason I asked the question is that I had some experience once with this system of prize awards, and the first year the system was in effect everybody worked. The second year, those who were not so fortunate as to win an award were more or less of the opinion that it was not fairly decided, and it built up more of a grudge than it did a contest for better effort.

Mr. E. T. Howson:—I think there is no question but that if the method under which the award is made does not have the confidence of the men whose work is being inspected and checked, it will fail, but the roads that have followed the plan year after year advise that they have little difficulty from lack of confidence. The men do work for those awards.

The outstanding method, I think, is that of the Pennsylvania, which has a most detailed system of inspection, and in which the annual inspection has for years been

an outstanding event in the towns along the railway, even to the point where many of the railway towns dismiss their schools in order that the children may come down to the track and see the inspection trains go through.

Mr. H. C. Crowell (Pennsylvania):—I would like to ask the Committee Chairman if he knows whether or not any railroads are following Conclusion 3 and, if so, how successfully. It seems to me that would be a pretty hard job to work out in practice.

Mr. E. T. Howson:—The Committee has some information supporting the conclusion referred to by Mr. Crowell. They feel, from conference with and information from officers of those roads which have the inspection method in practice, that it is something those roads are working toward. Most roads have some more or less accurate ways of equating the work of various sections, as exemplified by the man allotment.

The Committee on Economics of Railway Labor has for years been in touch with one phase or another of the problem of equating sections, and knows that there is an increasing attempt on the part of the roads to equate sections, possibly not entirely accurately but it is in the direction of accuracy. Each year we are moving closer to a more fair, equitable allotment of forces. The nearer we can approach that, the more equitable will be the awards for efficiency based on performance.

The President:—Is there any other discussion, gentlemen? Mr. Howson, I have a good deal of difficulty to know how, in No. 3, you would arrive at the man-hour. That is not only dependent on the man-hours that may be worked for that particular year. The man-hours may have been worked the previous years on one section or one part of track, and not on another, which would throw that out of balance.

Mr. E. T. Howson:—Of course, no absolutely accurate basis has yet been devised for the equation of forces or man-hours because there are conditions which, as you point out (work done in the previous year, difference in climatic conditions on sections not far removed, etc.), that affect the work the individual gangs are required to do, and have an effect also on the results of their work.

This is an attempt to approach a fair basis of rating rather than to say that it is an absolutely accurate formula that can be worked out, with our present state of maintenance, to complete accuracy.

The President:—Is there any further discussion?

Chairman F. M. Thomson:—Subject (5), Relative economies of brush versus spray painting. Mr. G. M. O'Rourke, Chairman of the Sub-Committee, will present the report for this Sub-Committee.

Mr. G. M. O'Rourke (Illinois Central):—The report appears on pages 398 to 402 inclusive in Bulletin 343.

Pertinent portions of replies to questionnaires received from leading railroads occur about two-thirds of the way down on page 398. An exhaustive study was made by the Sub-Committtee of various periodicals, and extracts where reference was made to the relative economies of brush versus spray painting are given on pages 399 and 400. Opinions regarding the economical dividing line between hand and spray painting are given on page 400, about half-way down the page.

For those who wish to go into the subject further, there is a bibliography on page 401. The conclusions of the Committee are:

"(1) That there is a distinct saving in cost and a benefit in better results, greater durability and satisfactory appearance through the use of paint spray equipment.

"(2) That railways are warranted in extending the use of spray equipment to small lattice work and trim on structures by the use of shields, proper equipment and various types of nozzles for that purpose and reduce brush work to a minimum.

"(3) The greatest economies can be obtained by using spray equipment with specialized forces kept on this class of work."

The recommendations of the Committee are that this report be received as information and the conclusions printed in the Manual. Mr. President, I move the adoption of the recommendations for inclusion in the Manual.

The President:—You have heard the motion. Are there any comments, or any discussion?

(The motion was put to vote and carried.)

Chairman F. M. Thomson:—Subject (6), Revised plans for outfit cars for the Maintenance of Way department employees. This Committee reports progress only, and recommends that the subject be continued.

The President:—If there is no objection, it will be so received.

Chairman F. M. Thomson:—Subject (7), Use of motor trucks in Maintenance of Way and Structure work. This Committee reports progress, and recommends that the subject be continued during the ensuing year.

The President:—If there are no comments or objections, the report will be so received.

Chairman F. M. Thomson:—Subject (9), Gang organization and methods of performing Maintenance of Way work, including revision of time studies now in the Manual.

The Sub-Committee has done considerable work since the publication of this report, and I am asking Mr. C. H. R. Howe to give you a brief synopsis for your information of the status of this report at the present time.

Mr. C. H. R. Howe (Chesapeake & Ohio):—The Committee wishes to state that the revised rail laying schedules mentioned above, insofar as hand laying methods are concerned, are complete and ready for publication.

The Committee is now securing data with which to establish schedules covering the operation of rail laying gangs that are fully equipped with mechanical appliances for handling this work. The necessary time studies for this are practically complete, and the schedules will be ready for publication with our next report.

The President:—If there is no objection, it will be so received.

Mr. Thomson, I think this concludes your report We are very appreciative of the splendid and excellent work of yourself and your Committee (Applause).

Mr. E. E. R. Tratman (Engineering News-Record—by letter):—In view of the increasing development of the floating-gang system for ordinary track maintenance, the Committee might be requested to widen its scope and consider or recommend methods of inspection and awards suitable for sections or districts in which maintenance is handled mainly by floating gangs.

DISCUSSION ON WATER SERVICE AND SANITATION

(For Report, see pp. 259–295)

Mr. R. C. Bardwell (Chesapeake & Ohio):—Before this Committtee presents its report, it is believed to be fitting that the Committee announce it has sustained a very severe loss during the past year through the death of Dr. Charles Herschel Koyl, Engineer of Water Service, Chicago, Milwaukee, St. Paul & Pacific Railroad. Dr. Koyl had been a member of this Committee since 1920. He was a gentleman of the highest type and an investigator of rare ability. He was a regular attendant at the meetings of the Association and of the Committee, and contributed freely of his time and talents in the preparation of its reports. The inspiration of his high integrity, fine character and kindly personality will be missed by all.

Report of Committee XIII—Water Service and Sanitation, is presented on pages 259 to 295 inclusive of Bulletin 342.

The first subject under the heading "Revision of Manual," appears on page 260.

Due to some confusion in terms applied to various forms of corrosion, it was considered advisable to add definitions in the Manual concerning railway water service to distinguish between grooving, pitting and embrittlement. These definitions recommended by the Committee are shown on page 260.

"GROOVING.—Localized corrosion in strained areas, occurring in well-defined lines such as long bends and around staybolts or bracing.

"PITTING.—Localized corrosion occurring in spots which frequently penetrate the entire sheet of metal.

"EMBRITTLEMENT.—Failure of boiler metal resulting from intercrystalline cracks."

I move these definitions be accepted for publication in the Manual.

The President:—You have heard the motion, gentlemen. Is there any discussion?

(The motion was put to vote and carried.)

Chairman R. C. Bardwell:—On pages 261 to 266 inclusive, your Committee is submitting its recommendation for revision of that portion of the Manual appearing on pages 921 to 925 inclusive, under the heading "Standard Methods of Water Analysis and Interpretation of Results." The original methods were submitted and adopted in 1924 as an aid to standardization in reports of boiler water tests. This subject has been considered jointly by various committees of other technical associations during the past seven years, and agreement has been reached covering changes which seem desirable. These changes and improvments have been incorporated in our recommended revision.

Since publication of Bulletin 342, the recommendations have been referred to a number of interested railway officials and many favorable comments have been received. The following suggestions have been made which warrant favorable consideration:

First, on page 261, under the list of negative radicals, change the term "hydroxide" to follow instead of precede the term "carbonate."

Second, in standard form of water analysis report on page 261, insert the term "magnesium sulfate" between "calcium sulfate" and "calcium chloride."

Third, in the second line on page 263, insert "phenolphthalein indicator" after the words "to faint pink."

Fourth, on page 263, in the third from the last line in the last paragraph of Section 4, eliminate the words "of soda-ash" after the words "shows an absence."

With these changes, we move that the recommended revision be approved to replace present material in the Manual on pages 921 to 925 inclusive.

The President:—You have a motion before you. Is there any discussion?

(The motion was put to vote and carried.)

Chairman R. C. Bardwell:—There has been a need evidenced for standard specifications to cover salt used in the regeneration of zeolite water softening which already appear in the Manual. Information obtained from manufacturers and railroads using such material was solicited, consolidated, and is presented on pages 266 to 268.

It is the recommendation of the Committee that these specifications be approved for inclusion in the Manual, and I so move.

The President:—You have a motion before you. Is there any discussion?

(The motion was put to vote and carried.)

Chairman R. C. Bardwell:—The progress report on Subject (2), Pitting and Corrosion, will be presented by the Sub-Committee Chairman, Mr. J. H. Davidson.

Mr. J. H. Davidson (Missouri-Kansas-Texas Lines):—This report appears on pages 268 to 270 of Bulletin 342. This is a summary of the results obtained during the past five or six years by representative railroads with various methods that have been proposed for inhibiting pitting and corrosion in locomotive boilers.

We desire to call your attention again to the severe damage that locomotive boilers may sustain while the engines are in storage, and at this time when so many locomotives are stored it promises to become a subject of some importance. The necessity for providing protection against this corrosion while in storage is something that should be given more consideration than it has had in the past. This report outlines a couple of methods that have been used with success

The report is offered as information, and I move that it be accepted as such.

The President:—Are there any comments? If there is no objection, it will be so received.

Chairman R. C. Bardwell:—The progress report on Subject (3), Value of Water Treatment, will be presented by Mr. R. E. Coughlan.

Mr. R. E. Coughlan (Chicago & Northwestern):—Progress report for the past year appears in Appendix C, pages 270 to 284 of Bulletin 342.

In last year's report your Committee endeavored to assemble data and principles from which each individual case of water correction could be considered to make natural water suitable for locomotive use.

It was reported that few natural waters are suitable for boiler use without some form of water treatment. The various limits and resulting difficulties encountered were shown with the various qualities of water. No fixed rule could be established which would cover all cases and operating conditions, although with certain exceptions definite limits were set for the different forms of internal and partial treatment.

In the report of this year your Committee has gathered such information as is available of the various methods of applying soda-ash either alone or in the common combinations and commercial variations of chemicals used under the name of internal treatment or proprietary boiler compounds. These devices may be used either alone or as an auxiliary treatment in districts where complete softening is not in use at all stations.

In all methods of water treatment, including complete softening, the keynote of successful results is constant supervision, as no one factor is more essential than a competent checking and correction of any irregularities of chemical treatment or mechanical facilities.

This report is offered as information, and I move that it be so accepted.

The President:—If there is no objection, it will be so received.

Chairman R. C. Bardwell:—The final report under Subject (4), Washouts, Water Changes, and Blow-Down of Locomotive Boilers as Influenced by Water Conditions, will be presented by the Sub-Committtee Chairman, Mr. E. M. Grime.

Mr. E. M. Grime (Northern Pacific):—The report of this Sub-Committee is found on pages 284 to 288.

As in most other lines of endeavor, the water engineer must be a salesman. Not only must he furnish a high-class product but he must also show his clients in the mechanical department how to get the best results from its use. Water softened primarily for the protection of the boilers must at the same time interfere in no way with practical operation.

Your Sub-Committee herewith presents a résumé of the average operating arrangements on a good proportion of the leading railways of this country. Practically every railway and even several districts of the same railway each has its own particular water problem, and it is impracticable to lay down anything but good general practice, with the suggestion that individual cases be handled as necessary to suit local conditions.

The diagram on page 286 gives a graphic representation which was worked up for a special case showing the gradual accumulation of foaming salts, and the blow-down

practice adopted to hold down the concentration to the point where operation will be satisfactory.

The preparation of a similar data sheet for difficult operating districts should be of considerable value to those responsible for locomotive operation.

From a study of this subject, your Committee arrives at five conclusions, as given on page 288, and it is recommended that these be included in the Manual. I will read these conclusions.

"1. A schedule for washouts must be governed by local conditions and particularly the quality of the feedwater. This makes it impractical to outline a program for general application. In districts where all the water is fully treated, thirty days between washouts is usually the practice, with water changes between as found desirable.

"2. Schedules for blowing down likewise vary with the water quality and should be determined for each district from a study of the boiler water concentrations and the field operation.

"3. Water changes are merely exaggerated blow-downs, and necessity for same will depend on the blowing schedule while enroute over the district and the water quality.

"4. Here, as elsewhere, the human factor is of first importance. The man at the throttle can make the best of water carry-over with the steam by careless handling. If he has been well-trained, he will carry a reasonable amount of water in the glass, sense the proper time and amount to be blown, and turn the locomotive over to his successor in practically as good condition as when it left the engine house.

"5. Adequate supervision and chemical check tests are necessary to accomplish regular and satisfactory results and secure maximum economies from the regulation of blown-down, water changes and washout schedules."

I move that we adopt these for publication in the Manual.

The President:—You have heard the motion. You have no doubt listened to these conclusions with interest. It is a very interesting report, one that means a great deal to the railroads in which we are interested, and I particularly ask if there are not some who would like to ask some questions, or who would like to discuss some of the particular features of this report.

It must be a 100 per cent report, because everybody seems happy over it, so I congratulate you.

(The motion was put to vote and carried.)

Chairman R. C. Bardwell:—Your Committee has assembled considerable information pertaining to Subject (5), Pumping Equipment, and (6), Track Pans, and desires to report progress at this time, and recommends that these subjects be reassigned for further study and report next year.

The final report, Subject (7), Coagulants, will be presented by Mr. R. M. Stimmel.

Mr. R. M. Stimmel (Chesapeake & Ohio):—The report appears in Bulletin 342, page 289.

A questionnaire concerning the use of coagulants was sent to several railroads. Answers indicate that approximately 75 per cent use a coagulant. Two purposes were reported as served: The removal of mud and suspended matter, and the production of a treated water with lower residual hardness.

Several coagulants have been tried, but only three, sodium aluminate, sulphate of alumina or "filter alum," and sulphate of iron or copperas, are in general use at present.

Answers indicated that very little data has been compiled in dollars and cents as to savings effected by the use of coagulants, but that the additional cost resulting from their use is justified in the reduction of precipitation and elimination of mud deposits in boilers. This report is submitted as information.

The President:—Unless I hear objection, it will be so received.

Chairman R. C. Bardwell:—In regard to Subject (8), Progress being made by Federal and State Authorities on Regulations pertaining to Railway Sanitation, collaborating

with the Joint Committee on Railway Sanitation, A.R.A., your Committee desires to call attention to the fact that the Joint Committee of the American Railway Association, on which your Association has three representatives, published a 108-page report under date of November 24, 1931, covering its activities and investigations to that date, which was distributed as information only. This publication was not reviewed in the report of your Committee due to our report being furnished the Secretary before the Joint Committee report was received. This will be reviewed and abstracted for the next meeting. Meanwhile, anyone so desiring can obtain a complete copy of the report from J. C. Caviston, Secretary, 30 Vesey Street, New York.

The report on Subject (9), Sewage Disposal Facilities where Sanitary Facilities are not available, has not been completed. Considerable data has been completed by the Sub-Committee Chairman, Mr. W. P. Hale, and it is expected that final report will be made during the coming year.

The final report is Subject (10), Advisability of Standardizing Valves and Packing for Water Service Pumps, which will be presented by the Sub-Committee Chairman, Mr. J. P. Hanley.

Mr. J. P. Hanley (Illinois Central):—The report of the Sub-Committee on Pump Valves and Packing appears on pages 292 to 294 of Bulletin 342.

In investigating this matter, we secured information from manufacturers, the Bureau of Standards at Washington and from 22 railways having representation on the Water Service Committee.

After considering this information, we believe little or no necessity exists for specifications for rubber pump valves. This material is being satisfactorily secured from current manufacturers' stocks by giving a brief description of the dimension of the valve and the character and temperature of the liquid to be pumped.

The question of packing covers a broader field than valves, but we found only one railway using standard specifications for this material. The Bureau of Standards, however, have extensive specifications for many types of packing and we present a list of some of these specifications that could be used in the railway field. This list appears on page 293, and as it is rather brief I will read the list:

"Rubber Goods, General Specifications
Packing; Asbestos, Sheet, Compressed
Packing; Rubber Wire Insertion
Master Specifications for Flax Packing
Packings and Gaskets, Rubber (molded sheet and strip)
Master Specifications for Packing, Asbestos, Wick and Rope
Master Specifications for Cloth Insertion Rubber Packing
Master Specifications for Packing, Hard Fiber Sheet
Master Specifications for Diaphragm Packing
Master Specifications for Rubber Pump Valves."

Copies of these specifications may be obtained from the Superintendent of Documents, Federal Printing Office, Washington, D. C. for five cents a copy. We did not think it advisable to take up space in this Bulletin to reprint them at this time.

On page 294 we present a packing chart which may be used for listing approved brands of packing now on the market for water service pumps. The use of this chart would be convenient for water service and store departments. Its use would have a tendency to reduce numerous types of packing now carried in stock to an approved minimum.

The conclusions to the report also appear on page 294, and are as follows:

"(1) Specifications for packing cover many individual types of unsimilar materials and construction as indicated by the Federal list of specifications. The packing specifica-

tion recommended for consideration with the report covers a limited number of packings most generally used by railways.

"(2) Specifications for rubber pump valves cover a limited field and may be handled satisfactorily by specifications or by ordering from manufacturers' catalogs. Specifications are not usually required.

"(3) The use of a chart for ordering proprietary brands of packing for certain types of pumps is satisfactory. It is particularly recommended for use where specifications do not exist."

This report is offered as information, with the exception of the packing chart shown on page 294, and the conclusions which I believe could be used in the Manual to advantage and I would like to make a motion to that effect.

The President:—You have heard the motion, gentlemen. Is there any discussion?

(The motion was put to vote and carried.)

The President:—Mr. Bardwell, I think this completes your report. You have certainly gathered much useful data which will be of much benefit. The appreciation of the Association is expressed (Applause).

DISCUSSION ON BUILDINGS

(For Report, see pp. 405–438)

Mr. A. L. Sparks (Missouri-Kansas-Texas Lines):—The report of the Committee on Buildings will be found in Bulletin 343, beginning with page 405, and consists of ten subjects, the first of which is Revision of Manual, on which we have no change to recommend at this time.

Subject (2), Preparation of Specifications for Buildings for Railway Purposes. I will ask Mr. F. R. Judd, Chairman of this Sub-Committee to report.

Mr. F. R. Judd (Illinois Central):—This Sub-Committee is not submitting any matter for publication in the Manual at this time. We have submitted and printed in this Bulletin under Section 30, which is divided under headings A, B and C, Specifications covering Steel, Brick and Reinforced Concrete Chimneys, with certain addenda which can be used with each of these specifications. These three specifications, and certain specifications which were published last year, are put forward as information with the hope that the Association will give us the benefit of their criticism in the coming year so that they can be presented as Manual matter at the next convention. I might say we already have some written criticisms on the chimney specifications, which the Committee will take under consideration, with any other criticisms which may be submitted to us during this coming year.

The President:—Unless we hear objection, it will be so received, Mr. Judd.

Chairman A. L. Sparks:—Subject (3), Various Types of Train Sheds, will be found in Appendix B. I will ask Mr. G. A. Rodman, Chairman of the Sub-Committee on this subject, to please report.

Mr. G. A. Rodman (New York, New Haven & Hartford):—In this discussion the term "train shed" is intended to include all types of platform shelters and shelters for passenger trains at stations and terminals.

This information was gathered by a form letter sent out to all the principal railroads, and the results have been tabulated. You will find at the end of the report two statements showing the principal features.

This report is submitted as information, and it is recommended that it be accepted as such.

The President:—Unless there is objection, the report will be so received.

Chairman A. L. Sparks:—Subject (4), Freight House Doors, appears in Appendix C. This report includes all the various types of doors that are in common use on railroads, and it is offered only as information. We would like to recommend that it be received as information only and the subject discontinued.

The President:—Is there any objection to this recommendation? I hear none, therefore it will be so handled.

Chairman A. L. Sparks:—Subject (5), Use of Welding in Buildings, collaborating with Committee XV—Iron and Steel Structures.

Since an extensive report on the use of welding in railway buildings is published in Vol. 32, pages 559 to 587 inclusive, your Committee has no further information to submit at this time and recommends the subject be discontinued.

The President:—Is there any objection to this method of handling? As we hear none, it will be so ordered.

Chairman A. L. Sparks:—Subject (6), Sidewalks and Station Platforms, is found in Appendix D. I will ask Mr. A. C. Irwin, Chairman of the Sub-Committee handling this subject, to please report.

Mr. A. C. Irwin (Portland Cement Association):—About the only thing that needs to be said concerning this report is to call attention to the fact that part of it, under the heading of "Sidewalks," is considered by the Committee as properly belonging to Subject (2) as a general assignment from year to year, and refers to the preparation of Specifications for Railway Buildings. It is assumed by the Committee that it can initiate preparation of specifications for sidewalks without this special assignment.

The subject-matter is offered for information with the recommendation that the subject be discontinued.

The President:—Is there any discussion of the subject?

Mr. C. W. Baldridge:—Near the top of page 432, the Committee have shown a list of conditions which should be observed in preparing for sidewalks. I would like to suggest that they add the term "drainage" to that list.

Mr. A. C. Irwin:—The Committee will accept that suggestion.

Mr. Edwin F. Wendt (Consulting Engineer):—I notice that this Committee has recommended in three different instances that subjects be discontinued. The previous subject, as I understood it, was the welding process. That process is just in its infancy and great expectations are in store in the way of economies through its use. I cannot understand why the Committee would recommend that consideration of the subject be discontinued, and I would appreciate an explanation as to the reasons for the recommendation.

The President:—My understanding is the Committee states they had made a complete report last year on the subject.

Chairman A. L. Sparks:—Mr. Judd would like to report briefly on that.

Mr. F. R. Judd:—When the report on welding was submitted at the last convention, it was suggested that it be discontinued for the time being. The ground was very well covered in that report, and it was thought it would be too soon to be able to add very much information to it, as far as this Committee is concerned.

It is my understanding that this subject is also assigned to the Committee on Iron and Steel Structures, and they are continuing their studies along the line of general welding. Ours was purely in connection with the welding of structural steel for building work. For that reason, on account of the fact that the report was as comprehensive as we thought we could make it at that time, we recommended discontinuance of the subject. Until sufficient time has elapsed to enable us to add more information as the process is developed, it is thought best to discontinue the subject for the time being.

Mr. Edwin F. Wendt:—I think that puts a new light on the whole subject. As I understand it, the Committee simply wishes to have the subject lie dormant. There is a great future for the process of welding in the construction of buildings, and we have manufacturers in this country who are experimenting with the construction of dwelling-houses in the hope that the new process may be greatly to the benefit of the public in the reduction of cost.

I think the explanation of the Chairman is of interest to the Board of Direction and the Committee on Outline of Work with respect to the future program.

The President:—If I hear no objection to it, I would suggest that this matter be referred to the Committee on Outline of Work to determine whether this Committee should continue a further study of the subject. If that meets with the approval of the Association, it will be handled that way. Are there any objections?

Chairman A. L. Sparks:—On Subject (7), Modern Methods of Heating Small Railway Buildings, showing Comparative Advantages of Warm Air, Hot Water, Steam and possibly Fan Unit Systems, your Committee has collected considerable information and data, and desires to report progress. We would like very much to have all the help you will give us on this subject. We feel it is a very important subject. Heating methods and systems are being rapidly revolutionized, and we know that many of you gentlemen have new methods of heating in many of your stations, and we would be mighty glad to know about them. We have received very little comment from any of you thus far, but we would like to have more.

On Subject (8), Design and Construction of Modern Fruit and Produce Terminal Buildings, and on Subject (9), Relative Merits of Wood and Fireproof Roof Structures which should include Wood, Hollow Tile Fireproofing, Concrete and Cement Tile, etc., your Committee desires to report progress and asks that the subjects be reassigned for another year.

The President:—Unless there is objection to that, it will be so received.

Chairman A. L. Sparks:—Subject (10), Specifications for Concrete Used in Railway Buildings, is shown in Appendix H, and I will ask Mr. W. T. Dorrance, Chairman of this Sub-Committee handling this subject, to please report.

Mr. W. T. Dorrance (New York, New Haven & Hartford):—Specification for Concrete used in Railway Buildings is a continuation of the general subject of Specifications for Buildings for Railway Purposes, which was first assigned to this Committee in 1920. We have from time to time offered for publication in the Manual as recommended practice specifications covering various classes of work entering into railway buildings. This was following an outline approved ten or twelve years ago so that the specifications would be in convenient loose-leaf form and could be used in any combination that might be desirable for any project under consideration. This general outline was published as Bulletin 247 in July, 1922.

The section covering Concrete under this general subject of Specifications for Railway Buildings was originally prepared and published in 1921 and has been revised from time to time by your Committee, and at the convention of 1931 was offered to the Association as information with the idea that it would be presented for publication in the Manual after the Association had an opportunity to review the specification and give us the benefit of any criticisms.

We now offer this specification, which appears on pages 549 to 556 of Bulletin 334, or in Vol. 32 of the Proceedings, for publication in the Manual. It seems unnecessary to read the separate paragraphs, Mr. President. The specification has been before the Association for a year.

The President:—Gentlemen, there is a motion before you. Is there a second? Is there any discussion?

Mr. H. C. Crowell (Pennsylvania):—I would like to ask if these concrete specifications are the same as the specifications for concrete developed by the Masonry Committee and, if so, why it is necessary to repeat seven pages.

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—As Chairman of the Masonry Committee, I will answer that question by reading the results of the Joint Committee meeting between the Buildings Committee and the Masonry Committee at which this subject was discussed.

In the course of this discussion, it was brought out that the material is a duplication of what is already in the Manual as concrete specifications. It was then held that this was a matter for the Board of Direction to decide whether they wanted two sets of specifications. After a thorough discussion, it was voted by the Masonry Committee that I send a letter to Mr. Sparks to the following effect:

"Resolved, That the Chairman of the Buildings Committee and the Board of Direction be informed of the objection of the Masonry Committee to the printing in the Manual of the proposed Specifications for Concrete Used in Railway Buildings, on the ground that while the material covered by the proposed specifications is similar to that of the Masonry Committee now in the Manual, there have been important omissions as well as immaterial changes, which would result, if the proposed specifications were adopted, in the presence in the A.R.E.A. Manual of two specifications for the same material of construction not identical in form for the corresponding provisions though identical in intent with serious omissions of important matter now included in the Specifications for Concrete."

On that ground we object to the inclusion of the specifications in the Manual as recommended practice for concrete for use in buildings.

One of the members of our Committee, not a railroad employee, took the trouble, time, and the expenditure of money to make a comparative set of tables, pasting on one side the provisions of the Masonry Committee and on the other the Buildings Committee to show this difference which was summarized in this letter.

I therefore object for the Masonry Committee, and personally, to the inclusion of this in the Manual.

Mr. B. R. Leffler (New York Central):—I am going to defend the Buildings Committee because I do not think it is necessary to have two specifications for concrete that are alike. They are to serve two different purposes. Specifications for bridges should be far more rigid than for building work. We recognize this in other building material. In steel work the specifications for bridges are far more rigid than for building work, and specifications for timber for bridges are far more rigid than for building work.

There is no reason why we cannot have two sets of specifications for concrete masonry, one for building work, and one for bridge work.

Let's see what some of the differences are. First, the primary quality in bridge masonry, as we are now recognizing more than ever, is durability. In building work, durability is a minor problem because a building is not subject to the destructive forces that bridges are. Nearly all masonry work in connection with building, with the exception of the foundation walls—I am referring particularly now to the framework of a reinforced concrete building—is not subject to the disintegrating influences that bridge masonry is subject to. As a consequence, you can have poor aggregate in building work; you can use more water in order to obtain workability, and you must have more workability on account of the extensive use of reinforcement and the narrow thin pieces that are used in a building frame.

In building work, the primary thing is sufficient strength. As long as these specifications bring out those qualities in the building work, I am in favor of the separate specifications for building work.

In bridge work, your strength naturally follows if you get the durability within certain limits. I think there is ample justification for two different specifications.

Now, as to possible inconsistencies, of course those should be ironed out, but if the Masonry Committee is thinking that these specifications should be alike, I think they are on the wrong track. In other words, specifications should be made to fit the service of the thing that is specified and not for the purpose of having them alike. In the last few years, the world has been in the standardization game. I think standardization is all right up to a certain point, but I would not like to live in a world where everything was exactly alike. We would have no progress.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—The first remark I want to make is to answer Mr. Leffler on one point. The specifications now in the Manual were not put there by a bridge committee. They were put there by the Masonry Committee, and a concrete building is a masonry structure the same as the concrete part of a bridge is masonry.

As to the matter of the specifications themselves, the 1929 Manual has the Masonry Committee's specifications for concrete beginning on page 566 and extending to page 582, 16 pages devoted to specifications.

The Buildings Committee now propose to include in the Manual the specifications which were printed in Bulletin 334 last year beginning on page 549 and extending to page 556, or seven additional pages on the same subject, the major portion of which has almost the same meaning.

It appears to me that the Buildings Committee should do as other committees who have some work on concrete matters do, refer primarily to these specifications on concrete now in the Manual, except—then name such exceptions as fit their conditions.

I think we should reject the publication of these additional seven pages of concrete specifications in the Manual.

Mr. W. T. Dorrance:—I want to bring out the fact that the Buildings Committee is not defending its action in preparing these specifications. In 1921, the Committee on Buildings, in their subject, Specifications for Railway Buildings, outlined their procedure, including the subjects which they intended to cover, and concrete was listed at that time. In 1924 a specification for concrete for building work was submitted. The Masonry Committee took the same objection at that time and were overruled to the extent that it was decided it was not a subject to be decided or discussed on the floor of the convention; it was not a matter for the floor of the convention to determine. The subject-matter was referred back to the Board of Direction. The Board of Direction, after that meeting, reassigned the subject as a special subject to the Buildings Committee. It was not assigned as it had been before, but was reassigned as a special subject.

Since that time, the Masonry Committee has been trying to comply with the requirements of the Board of Direction and the Committee on Outline of Work in presenting a specification. So if it was decided at that time that the question had to be submitted to the Board of Direction, then the same logic holds true at this time. If the Board of Direction had decided to go along with the Masonry Committee in their objection at that time, they would not have reassigned the subject to the Buildings Committee and had us wasting our time in preparing and working on the subject.

What we have done is to take the fifteen pages of the Masonry Committee's specifications and eliminated those parts which are not necessary for building work. We

have boiled that down to seven pages, including some matter which we have added. Any railroad that decides to send out a specification along these lines will have to do the very thing which the Buildings Committee has done very carefully, because there are many things in the Masonry Committee's specifications which are not necessary and will only make the work cost more, and will probably affect the bids because of the fact that the type of contractor on building work is oftentimes considerably different than the type of contractor on bridge work. He has a smaller organization and has not time to try to analyze the specifications as to what does apply and what does not apply, and in that way it will affect bids that come in on the work.

We feel the Masonry Committee have done their duty in presenting this matter to you because it has been reassigned to us from year to year, and we feel that the railroad members of this organization are entitled to the work rather than having their own organizations go through and do the work individually that has been done by the Buildings Committee in preparing this specification.

Mr. J. B. Hunley (Cleveland, Cincinnati, Chicago & St. Louis):—I agree with Mr. Leffler that these are entirely different subjects that should be covered by two specifications, but inasmuch as there is now a Joint Committee working on Masonry specifications, and that those joint specifications will cover building construction as well as masonry construction, why should this not be accepted as a tentative specification and not put in the Manual, because when the new masonry and building specifications come out they will both be revised? I think the specifications as they stand are very valuable. It is very true that if you are calling for bids on concrete building construction you will have to eliminate a great deal from the bridge masonry specifications to get proper bids. Why not accept it as a tentative specification and not put it in the Manual? I think it is a mistake to revise the Manual every year unless necessary.

Mr. C. C. Cook (Baltimore & Ohio):—I do not believe the Association is in position to pass upon the merits of this specification in light of the statement made by the Chairman of the Masonry Committee, to the effect that there are serious omissions in this specification and other material changes, as compared with the specification which the Masonry Committee now have.

The Committee on Outline of Work was confronted with this assignment for the last two years. Last year they hoped to get the matter settled by having collaboration between the Masonry Committee and the Buildings Committee. Unfortunately, that collaboration did not start early enough in the year to enable the two Committees to harmonize their detail.

I think the major problem is the one stated by Mr. Leffler, on the one hand, and by Mr. Baldridge on the other, and I believe it would be a good thing for this Association to give an opinion as to whether or not there should be a separate specification for concrete by the Buildings Committee published in the Manual, supplementing the one that may be placed there, or is now there, by the Masonry Committee. I think it would help the Committee on Outline of Work to have a suggestion on that element of the problem, and I think the present specification now offered by the Buildings Committee should be held until next year so that they can again collaborate with the Masonry Committee.

Mr. F. R. Judd:—This specification was submitted to the Masonry Committee before the convention last year. They were asked for their criticisms because they were instructed by the Committee on Outline of Work to collaborate with the Buildings Committee. So they have had over a year to give us constructive criticism on the specification.

It was only through our own efforts that we really had one joint meeting, so we feel we have tried to collaborate. At the one meeting we had, the main subject under discussion was not the work of the Committee on Buildings; it was the work of the Committee on Outline of Work. The Masonry Committee took the stand that the Committee on Outline of Work should not have assigned this subject; that it was unnecessary. Of course, we could not act on that because the subject was assigned to us and we had to work on it.

We feel that the Masonry Committee has had ample opportunity to collaborate, but to my knowledge we have had no constructive criticism of any particular clause in the specification as we have submitted it so far. On this collaboration, the main idea all along has been to object to the assignment, which is the work of the Committee on Outline of Work, rather than to the work of the Buildings Committee.

Mr. Meyer Hirschthal:—I will have to reply to that because it is a question of veracity now.

There were no letters that were not replied to. Specifications as compiled by the Buildings Committee before the last convention were presentd to me for criticism. I returned them to the then Chairman of the Masonry Committee who, in turn, turned them over to the Buildings Committee.

On September 28, in reply to Mr. Sparks' letter to me, I wrote as follows: "I regret very much that the correspondence on the matter of 'Concrete Specifications for Buildings' did not reach me until today, just a week after the meeting of the Masonry Committee, where it would have been a good place to take up the matter. This question of separate specifications for concrete in buildings has been a 'sore spot' for some time and I am still personally of the opinion that concrete both as to design and construction should be the same for all structures with special modification for any particular type.

"I will not go into the various phases of the subject as it will get us nowhere, but wish to call attention to the fact that at the present time there is an attempt being made to comb the Manual and get one specification for structural steel for various uses rather than a separate structural steel specification for each type of structure. There is no question that the general conditions which govern a material of construction as to its composition and its quality could very well be set forth in one specification with additional qualities and methods for specific variations from the general specifications."

At the Chairmen's meeting last March, Mr. Sparks and I discussed this matter with Mr. Cook, and we decided definitely on a course of action. We decided that the Buildings Committee could prepare its specification, submit it to us, and where it differed from our specification we would revise our specification if we thought revision was necessary. We waived the question of a separate set of specifications because it was beyond our jurisdiction. It was up to the Committee on Outline of Work and the Board of Direction as to whether there should be two specifications or one.

The question now at issue is whether the specification as presented by the Buildings Committee should go into the Manual. Mr. Leffler has spoken in favor of that without having taken the trouble to compare what is in the present specification with that which is proposed.

The omissions are as follows: There is no provision for depositing concrete under water. That may happen in a building just as well as in a bridge. There is no provision for protective concrete covering; water-tight construction joints; concrete in sea water; concrete in alkali soil or water; decorative finishes; waterproofing.

That is outside the various minor details where there is slight difference in wording which in the case of a lawsuit on specifications would result in reference to a

specification that is in the Manual of the A.R.E.A. There are sixteen items of that character which would only take one meeting of the combined committees to iron out without any difficulty. We might just as well wait another year and get a correct specification as to rush one through with whatever is in it.

Chairman A. L. Sparks:—I do not desire to prolong this argument or discussion as the Chairman of the Committee on Outline of Work has already suggested the proper method, it seems to me, for the solution of this problem, but there are just one or two things I would like to comment on, and one is the letter of the Chairman of the Masonry Committee written September 28 in which he said he had not received a copy of the specifications of the Buildings Committee on concrete. I wish to say that in February the specification was published in the Bulletin, and I presumed the Chairman of the Masonry Committee had a copy of that Bulletin.

Another thing I would like to mention is that the Chairman of the Buildings Committee takes the stand that the Masonry Committee's Chairman's letter, which he wrote in regard to the inadvisability of publishing such a specification, should have been addressed to the Committee on Outline of Work and not to the Committee on Buildings. We have nothing to do with the subject of what specifications shall be published and what subjects shall not be published.

I move the adoption of Mr. Cook's recommendation.

Mr. J. A. Lahmer (Missouri Pacific):—I want to suggest that there is now a Joint Committee representing, I believe, five national technical societies engaged in the work of preparing specifications for concrete. According to a statement that was made on the floor, and that an examination of the proposed specifications will evidence, those specifications are intended to cover buildings as well as other structures. If it is feasible for them to do so, I suggest it would be well for us to try the same procedure.

Mr. C. C. Cook:—In order to get the matter before the convention, I would like to make my suggestion in the form of a motion. I move that the subject of the preparation of specifications for concrete by the Buildings Committee be referred back to that Committee for collaboration with the Masonry Committee and report next year.

Mr. W. T. Dorrance:—I will accept that in place of my motion.

Mr. S. S. Roberts (Interstate Commerce Commission):—I wish to second Mr. Cook's motion. It has been shown by the discussion that the Committees hold an honest difference of opinion as to that which is required of each. There are differences of opinion whether there should be two specifications or one, which precludes, at this time, passing on the specifications presented. The Committee on Outline of Work should like to know the will of the convention as to whether there should be one specification or two.

I think the matter of collaboration in this case is much like the instance that occurred between a Supervisor and his brother, an old section foreman, in the Louisville terminals of the Louisville & Nashville. The Supervisor found a rough crossing and he told his brother to "Smooth the crossing." A few days after that, he again rode over that same district. The crossing was still rough. He got off at the next station and walked back. When he found the foreman this colloquy occurred: "Pat, have you smoothed the crossing?"

"An' shur-r Oi have."

"Pat, smooth it agin."

So I think we should have a little more collaboration.

The President:—The Committee indicates they will accept Mr. Cook's motion as an amendment to their motion.

Mr. C. C. Cook:—May I suggest that the approval of my motion indicates that this convention wants two sets of specifications for concrete. That is the purpose of my motion.

The President:—I am glad you made that clear.

Mr. F. L. Nicholson (Norfolk Southern):—It seems to me we are not adhering to a principle that we should very closely adhere to, which is, not to duplicate effort. We have a Masonry Committee. That Committee should be competent to form a specification for any type of masonry, for any use. A Committee on Buildings, or any other group using those specifications could, by reference, include them in their specifications.

I believe the method suggested by my friend, Mr. Cook, of handling the matter by having the Committee on Buildings prepare specifications in collaboration with the Committee on Masonry is in reverse order. The Committee on Masonry should prepare the specifications in collaboration with the Committee on Buildings.

I believe when we get down to that principle we are going to avoid all the discussions we have had this morning. The Committee, of course, are only carrying out their orders or instructions from the Board. They cannot be blamed for that. They have done a good work, but we should try to avoid duplication of effort and not have assignment of subjects to a Committee that conflicts with another. It is a difficult problem. Apparently there is overlapping that cannot be avoided, but let's get it in the right Committee, that Committee collaborating with the Committee using it.

Mr. W. T. Dorrance:—I would like to call particular attention to the fact that in this specification work carried on over a period of nearly fifteen years, the Committee on Buildings have endeavored to collect and put in one place a set of specifications descriptive of general building work for the ordinary type of buildings that are run across in railroad construction, but not to completely cover the field of general building construction, monumental buildings or structures which might require special treatment. It has been our desire to give this general information in one place where it would be helpful to the ordinary run of railroad man, and we have covered it in perhaps a rather general way. We have in carrying out this plan already prepared a section covering General Conditions. (This is also covered by the Committee on Uniform General Contract Forms.) Sections covering—

Excavation,
Brick work,
Carpentry and Mill Work,
Lath and Plaster,
Hardware,
Painting and Glazing,
Plumbing,
Heating,
Stone Masonry.

(There has been no objection to stone masonry being included, although this is also covered by the Masonry Committee.)

Clay Hollow Tile,
Steel and Iron Work.

(There has been no objection to this, although this subject is also covered by the Committee on Iron and Steel Structures.)

Marble and Tile Work, Etc.

We firmly believe the subject of Concrete ought to be included in this general set of specifications prepared by this Committee in connection with the specifications for

various classes of work entering into railway buildings in order to make the subject of Specifications for Railway Buildings complete.

Mr. H. C. Crowell (Pennsylvania):—As the one who unconsciously started this discussion, I would like to close with this word.

It may be necessary to have a separate concrete specification for buildings. I do not know. Mr. Leffler says it is and I will take his word for it. But I do know that bad sand is bad for concrete whether it is in a bridge or in a building. The Masonry specification undoubtedly includes a very specific description of good sand. Similarly, the water-cement ratio holds in the mixing of concrete for a building as well as in the mixing of concrete for a bridge, and the Masonry Committee has gone into that in considerable detail. Why repeat those items in the specifications?

If the seven pages of specifications submitted by the Buildings Committee do not repeat anything that is in the Masonry Committee's specifications for concrete, well and good. I will admit I have not read them, but I am surprised that it takes seven pages to state the differences.

The convention will probably recall that last year I tried to keep 1500-lb. concrete in the Masonry specifications for the very purpose of this second grade concrete that Mr. Leffler wants to use, but I could not get anybody on the Masonry Committee to agree to the 1500-lb. concrete specifications.

Mr. H. Austill (Mobile & Ohio):—As my friend says, we have before us a problem of consolidating the structural steel specifications. Might I suggest that we now have in the Manual a general specification for timber. Then we have a code to select from that timber what you want to use for specific purposes.

I believe the Masonry Committee can prepare a specification and also prepare a code by simple reference to paragraph numbers for particular use, and in that way we will eliminate the duplication of a great deal of material in the Manual.

Mr. W. S. Lacher (Railway Age):—I would like to ask Mr. Dorrance, in view of what has been said about quality of concrete, whether he considers that the specification drawn up by the Committee on Buildings is less rigid in its requirements for insuring quality and durability of concrete than that developed by the Masonry Committee.

Mr. C. W. Baldridge:—I arise to ask a question in regard to Mr. Cook's motion. As I understood it, his motion was to refer the matter back to the Committee for another year's work, and later I think he took some of the Washington prerogatives and read something else into the motion to the effect that it would mean certain things.

If we want an expression of whether this matter should be handled by the Masonry Committee or the Buildings Committee, let's make it straight and vote straight on that one subject.

Mr. C. C. Cook:—My motion was that it be referred back to the Buildings Committee for a specification on concrete, which would mean, by approval, that this convention wants two specifications for concrete in the Manual, collaboration between the two Committees being had to iron out the detailed differences, if there are any.

The Chairmen of the respective Committees have agreed that they can work on the basis of preparing two separate specifications, if this convention wants them to do so.

Mr. C. W. Baldridge:—I move to amend Mr. Cook's motion in this manner: I move that the subject of specifications for concrete, which is now before us, be referred to the Masonry Committee.

Mr. T. L. Condron (Consulting Engineer):—I have compared the two specifications for the Chairman of our Committee. The comparison showed it was ridiculous to have two specifications published by the American Railway Engineering Association covering the same thing, but varying in some details more or less fundamental hence

more or less ridiculous when prepared, placing the Association in a very unfavorable light to other people.

Having been engaged in designing and superintending the erection of buildings for a good many years, I have found no difficulty whatever in using any first-class specifications for concrete, and the specifications in our office have largely been based on the specifications of the Masonry Committee of the A.R.E.A. for a good many years. We like to find one first-class specification for masonry and one first-class specification for structural steel, in the A.R.E.A. Manual, so that we do not have to compare two or more specifications for the same material side by side to see what we want to leave out or what should be put in.

The suggestion that the specifications of the Masonry Committee should be worked out in collaboration with the Buildings Committee seems to me to be an excellent and a workable one.

Chairman A. L. Sparks:—I can not see any need for the amendment that has just been brought before us. If we adopt the motion, the amendment is ambiguous. It does not mean anything. If the motion fails, we certainly will not need the amendment.

The Buildings Committee is just as anxious for a rigid specification as the Masonry Committee, and if the convention sees fit to have two specifications there will be absolutely no trouble in the two Committees getting together to decide what the specifications should contain.

Mr. G. S. Fanning (Erie):—If the amendment is carried, the original motion will not amount to very much. It seems to me it is unnecessary to have more than one specification. We have gotten along very well with one specification on the Erie for years. It is simply a matter of the different classes of concrete that should be in the specification.

The President:—Unless there is further comment, we will vote on Mr. Baldridge's amendment. So it will be entirely clear before the convention, will you re-state your amendment, Mr. Baldridge?

Mr. C. W. Baldridge:—I moved that the concrete specifications now before this convention be referred to the Masonry Committee for further action.

(The motion was put to vote and carried.)

The President:—Mr. Cook, did you want to say anything further?

Mr. C. C. Cook:—I think that clears the matter up for the Committee on Outline of Work so they can proceed.

The President:—Mr. Sparks, does that complete your report?

Chairman A. L. Sparks:—This completes the presentation of the Buildings Committee's report.

The President:—We want to express appreciation for this very excellent report, and the Committee is relieved with our thanks (Applause).

Mr. E. E. R. Tratman (Engineering News-Record—by letter):—One type of platform shelter roof not included in the report on trainsheds is for covering the wide platform between the station building and the first track, at through stations. In one case of this kind, with the platform 26 ft. wide, columns are set 8 ft. from the edge of the platform and carry I-beams which are anchored into the wall of the building and extend as cantilevers about 8 ft. beyond the columns. On this framing is the roof covering, which includes a line of ventilating skylights. A modification of this arrangement provided the columns with brackets of such length as to extend the roof over the first track and island platform. Columns are eliminated in some platform roofs of this kind. In one case a 16-ft. canopy has the outer end of its framing attached to tie-rods or chain suspenders anchored into the upper part of the wall of the station building. In a second

case, the concrete floor beams of the upper story (or roof of a one-story building) are extended as 27-ft. cantilevers for a canopy roof.

While earlier trainsheds of the Bush type are ventilated only by the smoke slots and have skylights in the flat roof over the platforms, some later designs provide ventilation and better lighting by triangular monitors over the middle of the platforms.

DISCUSSION ON MASONRY

(For Report, see pp. 621–663)

Mr. Meyer Hirschthal (Delaware, Lackawanna & Western):—I am on the other side of the fence now. The Masonry Committee's report is in Bulletin 344, beginning with page 621 and concluding with the end of the material up to page 663.

We present reports on: Revision of the Manual; Principles of Design of Plain and Reinforced Concrete; Science and Art of Concrete Manufacture; Specification for Foundations; Methods and Practices of Lining and Relining Tunnels; Study of Art of Repairing Deteriorating Concrete, and there will be a verbal report by Mr. Richardson on Subject (4), Contact with the Joint Committee, to inform you of what has transpired in the past year on this work.

All the subjects are asked to be reassigned. The only subject that is to be presented for printing in the Manual is that of Revision of Manual, Appendix A, which subject will be presented by Mr. J. F. Leonard, as Chairman of that Sub-Committee.

Mr. J. F. Leonard (Pennsylvania):—The first report of the Committee is that of Revision of Manual, and I do not believe it is advisable to take the time to read all the revisions, but I will try to take them one at a time and just explain the difference.

The first revision is that of Article 7, and it is a change in the wording of the sentence after the sizes of the material. The old wording was: "The maximum size of coarse aggregate shall be not more than 3 inches and shall be not more than four-fifths of the minimum clear space between reinforcement bars or mesh."

With the new wording, it reads: "The maximum size of coarse aggregate shall be not more than 3 inches nor more than one-half the minimum clear space between reinforcement bars or mesh opening, or between reinforcement and side forms; nor more than one-fourth the least dimension of the member." I move the adoption of this revision to the Manual.

The President:—You have heard the motion. Are there any comments?

Instead of voting on each particular change, we can go through and vote on all the changes at the same time.

Mr. J. F. Leonard:—The next revision is to add a paragraph to Article 10, reading: "Reinforcing materials shall be stored in racks in such manner as to avoid contact with the ground." I move the adoption of this recommendation.

Chairman Meyer Hirschthal:—I should just like to make a comment on that, just to show that we will take something from somebody. This is a verbatim copy of the Buildings specifications.

Mr. J. F. Leonard:—We propose to add a note to Articles 15 and 17 to the effect that: "The Canadian sack of cement weighs 87½ lb., and the Imperial gallon is 1.2 U.S. gallons, and in determining the gallons of water per sack of cement this should be recognized." I move the adoption of this addition.

Article 17 has at the present time five classes of concrete, from 3500 to 1500 lb. The proposed Article 17 has four classes of concrete, from 3500 to 2000 lb., with a maximum water content of seven gallons per sack of cement.

I would add that in the title of this particular article as written here "Amount of water" at the top should be offset and is the proper title to the article instead of appearing over the tabulation. I move the adoption of this revision.

Mr. J. B. Hunley (Cleveland, Cincinnati, Chicago & St. Louis):—That same change was proposed last year and was voted down by the convention. A 1500-lb. concrete is entirely satisfactory for certain work. I would not advocate its use where it is exposed to the weather, but it is entirely suitable in massive foundations. There is a saving of between one-half a sack and a sack per yard in 1500-lb. concrete over 2000-lb. concrete. This is no time to become extravagant. Let's retain the 1500-lb. concrete, so that those who wish to use it, and have found it economical and desirable, may know how to proportion such concrete. Let us use the cement we save by using 1500-lb. concrete for that portion of the work exposed to the weather, where we especially want a dense concrete.

This same question was thoroughly discussed last year and, as I said before, the convention voted that change down. As I remember it, Mr. Leonard threatened to put it in again this year, and every year until the thing was finally passed.

I see no harm in putting it in, but it might be well to add a footnote that such concrete should not be used in exposed work. I am not sure that I would hesitate to use it in any massive work above ground where it can be protected from weather effects.

Mr. B. R. Leffler (New York Central):—I am going to support Mr. Leonard. I think a 1500-lb. concrete is too poor a concrete for exposed bridge masonry, with eight gallons of water to a sack of cement. It savors too much of the old sloppy days. It is one of those points I tried to bring out in the discussion of the Buildings Committee.

It might be all right in a building where you have not the question of durability. I am continually keeping in my mind the durability of concrete. All these fine mathematical theories are all right in the designing room, but when you get out in the weather they seem to vanish.

I think 2000-lb. concrete is low enough for the majority of bridge masonry, even if the masonry is not exposed to flowing action. Take a pier, for instance, with the footing course below the frost line. You have a chance of water getting through the concrete. Just as soon as water goes through the concrete, there is either disintegration due to frost action, or, if frost action is not there, there is a chance for chemical changes.

Unless a very rigid note were inserted limiting the use of 1500-lb. concrete, I would be in favor of the revision.

Mr. J. B. Hunley:—I think it would be well to have such a note. I do not advocate for a minute using such concrete where it will deteriorate. We are quite as particular on the deterioration of concrete as Mr. Leffler is, but there are cases where the 1500-lb. concrete might be used.

There is a great deal of grade separation work where these foundations are very massive and built on perfectly dry ground. There is no danger of leaching and no danger of the deterioration of those foundations, and I would much rather use the cement we could save in the 1500-lb. concrete and put it above ground, and be that much ahead. Put in a note and make it very rigid.

Mr. Leffler said a while ago that such concrete might be satisfactory for building work. If you do want to use it, let it be defined and let us know how to make it, how many gallons of water per sack of cement.

I do think it is a mistake to eliminate it altogether. There are some places where it is not suitable, but I am confident it is suitable in a great many instances.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—The subject-matter which is published in the Manual of this Association is adopted as recommended practice.

That does not prevent people who wish to deviate from that practice doing so if they see fit, but they do not have the sanction of its being recommended by this Association.

I am in favor of adopting the revision as proposed by this Committee on that basis.

Mr. J. F. Leonard:—In reply to these remarks on the subject, naturally the Masonry Committee recognized the vote last year. They felt the vote was inadvisable and present it again because they feel very strongly that there is no such thing as 1500-lb. concrete. If you want to use a filling material with a little cement in it, well, that is anyone's privilege.

For some time the Masonry Committee has put in time and some gray matter to prepare a specification for making concrete, and there is no such thing in their specification to provide a dense, proper concrete mix which would have a strength of 1500 lb. per square inch.

The President:—In order to clear this up, I would suggest that you now vote on the recommendations of this Committee to and including the proposed change in the table under Article 17, all of which has been recommended by the Committee. A resolution has been offered and seconded.

Mr. H. C. Crowell (Pennsylvania):—May I say that I agree with Mr. Hunley in his remarks. I do believe there are places where 1500-lb. concrete has been put in, in spite of what the Chairman says that it is impossible to make 1500-lb. concrete. I could take you within five miles of this hall and show you some perfectly good concrete which was put in twenty years ago under my supervision, and in my ignorance I used a slump of somewhere between 6 and 9 inches. But the concrete is there today, and it is good concrete, if I do say it. The cement used was less than 1.1 barrels per yard. That includes everything from the footings to the copings.

Mr. J. B. Hunley:—Mr. Leonard said you could not make 1500-lb. concrete. We have been making 1500-lb. concrete for ten years, and it is true that the concrete that comes out of the mixer to be placed in the form is a very coarse mixture, even when using a large amount of sand and comparatively low slump. We place that with 3- and 4-inch slumps. It is also a matter of fact that in our test cylinders we get far greater proportionate increase in strength with 1500-lb. concrete, than we do with 3500-lb. concrete which we use in our arch rings. I have never known of any case in the tests we have made (and we have made thousands of them) where the 1500-lb. concrete mixed with something like eight gallons of water—has run below 2000, and the increase over the 1500 in that class is an increase larger, as a rule, than the 3500-lb. class. It is entirely possible to make an excellent concrete out of this class 15 with eight gallons of water to a sack of cement.

Mr. L. W. Skov (Chicago, Burlington & Quincy):—I think Mr. Hunley has just answered the question why 1500-lb. concrete should not appear in our Manual when he states that tests which he has made show what is termed 1500-lb. concrete is actually 2000-lb. concrete. It has been stated here several times that 1500-lb. concrete made 15 or 20 years ago is still in good condition. This undoubtedly is true, but at the time that concrete was placed the cement used was producing a concrete which was much slower in gaining strength than concrete made with the present-day cements. In making concrete, strength alone should not be the basis of design, thought should be given to permanency as well. It is my belief that concrete testing 1500-lb. in 28 days, made according to the best present-day methods, would have so little cement in it that it would not be durable.

Chairman Meyer Hirschthal:—On page 649 of the Masonry Committee's report there is a tentative table for minimum cement content for various classes of concrete. This is in line with the danger of getting too little cement for a given strength of con-

crete, where the cement is highly developed to give us better strength than we used to get.

Under 2½-inch aggregate, which is the aggregate you would use for mass concrete, the difference between two grades of concrete, 2500-lb. and 3000-lb., is .4 of a sack. The chances are that on a mass pier or abutment you use even heavier aggregate than 2½-inch, and the heavier the aggregate the lower the cement content, if you will notice, in that table. So instead of having 4.6 bags of cement per yard for the 2500, you probably would have something like 4.3, and for the 2000-lb. cement you would have 3.9, and for the 1500-lb., 3.5. Pretty soon you will have no cement, if Mr. Hunley has his way.

(The motion was put to vote and carried.)

Mr. J. F. Leonard:—The present Article 22 is revised to bring the reference to the A.S.T.M. specifications up to date. I move its adoption.

Article 31 has added to it a reference to the use of vibrators. I move its adoption.

Article 85 has added to it a change in the definition of "Position of Resultant Compression," to "Position of Resultant of Compressive Stresses".

Article 86 has added "h = Unsupported length of columns".

Article 106 has the capital "S" instead of the lower case. I think that completes them, and I move their adoption.

The President:—These are all the suggested changes in the Manual.

(The motion was put to vote and carried.)

Chairman Meyer Hirschthal:—The next subject to be reported on is that of Principles of Design of Reinforced Concrete Arches, Appendix B, beginning on page 624.

This is a continuation of the report which was presented last year, which we hope to bring to a conclusion at the next convention and present as a tentative specification for action, and to be printed in the Manual.

There are certain typographical errors which have crept into this which have been turned over to the Secretary, so that the matter, when printed in the Proceedings, will be correct.

This is offered as information, and to be continued. Unfortunately, Mr. Laird, the Chairman of this Sub-Committee, is absent and there will be no other presentation than the comments I am now making.

The President:—If there is no objection, it will be so considered.

Chairman Meyer Hirschthal:—The next subject is that of Progress in the Science and Art of Concrete Manufacture, Appendix C, on page 627. This gives you a summary of what has developed in the past year, and will be presented by Mr. L. W. Walter, Chairman of the Sub-Committee.

Mr. L. W. Walter (Erie):—In this report reference is made to the report of the Sub-Committee as published in the 1930 Proceedings, which was in many respects a cross-section of what, in our present knowledge, is the last word in basic principles of quality control.

This year's report deals with a few subjects of outstanding importance, in which noteworthy progress has been made over the last two-year period. It deals at length with the selection of concrete aggregates for durability, and includes suggested method of test for soundness of aggregates by use of sodium sulphate, separately for fine and for coarse aggregates, and suggests method of test for soundness of aggregates by freezing and thawing.

We have presented some interesting photographs intended to tie in with the service performance of poor aggregates in concrete, the weathering of the quarry from which

aggregates were taken, and also the behavior of the aggregates when submitted to the sodium sulphate and freezing and thawing tests.

If you will turn to page 632 you will detect a performance characteristic of poor coarse aggregates. Two photographs of the quarry indicate weathering of the rock when exposed undisturbed for a period of about eleven years in the quarry face.

Beginning on page 635 photos are used, separately in groups of three to a page, to indicate the results of tests of specimens from the several ledges tested. The top picture on each page is of five specimens used in the sodium sulphate test. The center picture in each series indicates the performance of the same five specimens when subjected to five cycles in the sodium sulphate test. The bottom picture shows the result of the freezing and thawing test of ten specimens taken from the same ledge. Referring to page 635, you may note that it took 125 cycles in the freezing and thawing test to break down the material to a degree comparable with the action of five cycles in the sodium sulphate test, whereas only 30 cycles in the freezing and thawing test were required with material illustrated on page 640.

Toward the conclusion of our report, page 648, we have attempted to deal with the water-cement ratio as affecting watertightness, and ultimate durability. We have gone somewhat into the question of the importance of safe-working consistency, and the significance of water gain with suggested means or methods for correction and control of water gain.

We have given quite some time to the study of curing or possibly, in other words, we may say maturing of concrete as affected by what we term early curing, and have attempted to deal with the water-cement ratio and cement factor, submitting at the conclusion of our report a suggested table which may serve as a safeguard against the quite too prevalent practice of designing concrete for strength alone without regard for the water-cement ratio, the cement content or the ultimate watertightness and durability. We have attempted, in a modest way, to relegate to the rear early strength as a dependable measure of ultimate watertightness and durability, and have suggested that instead of tying in a given water-cement ratio with a given strength, the strength in the right-hand column of the table be looked upon as the minimum strength that might be expected, falling below which investigation should be made to determine the cause of the low strengths.

This report in its entirety is submitted as information and I move that it be received as such.

The President:—Gentlemen, you have heard this report. Unless there is objection, it will be received as information, as recommended.

Chairman Meyer Hirschthal:—The next subject to be reported on is that on Foundations, Appendix D, page 650.

I want to call attention to the fact that this is pioneer work on the matter of foundations, and that the Sub-Committee deserves great credit for its taking the initiative in obtaining some information to secure engineering study of foundations as an engineering material. Mr. Rush will present the report as Chairman of the Sub-Committee.

Mr. D. B. Rush (Robert W. Hunt Company):—Some of you may remember that about two years and a half or three years ago we promised that this Sub-Committee would attempt to make progress in determining the bearing value of soils, and in building up a specification for foundations. There was a specification in our Proceedings, and I believe in the Manual some years back.

We have progressed to the point where we are now ready to start on the specifications. Initial to that, it was, in our opinion, necessary to develop a method of first

making soil tests, that is, to determine the probable bearing power of soils and then it seemed to us of vital import to be able to interpret the results.

As I told you, we promised progress and I am very happy to tell you that I believe we have made a little original progress, your Chairman but particularly on the part of Dean Williams and Mr. Stern, who have worked quite hard all of this last year on the subject.

I do not suspect that any of you gentlemen have read Appendix D. I do not think I would recommend reading all of it, but if you will turn to page 651, those of you who have it, you will notice the essence of the whole thing. It is simply that we have attempted to establish soil testing on a one square foot basis, preferably using a square plate. After this load test is made, we plot the curve and find the point that is analogous to the elastic limit of the material tested, whether it be gravel, clay, sand, or what not.

We have developed what we believe to be a fairly accurate formula for taking the information so obtained and actually applying it to footing design. That is outlined on page 651, and I do not believe it needs any further explanation at this time.

We would welcome any suggestions, either constructive or otherwise, that you gentlemen may care to write in to us. We have had some of both kinds. Inasmuch as this subject, as our General Chairman stated, is rather new we further feel that it does not conflict with anything that our Buildings Committee has published to date.

Chairman Meyer Hirschthal:—This is presented as information.

The President:—Unless there is objection, it will be so received.

Chairman Meyer Hirschthal:—In my preliminary remarks I stated we would have just a verbal report from the Committee on Contact with Joint Committee, and I will call on Mr. Richardson, Chairman of that representation, to tell you what has occurred during the year.

Mr. C. P. Richardson (Chicago, Rock Island & Pacific):—I will briefly report the activities of the Joint Committee. I believe we reported last year that the Committee was reorganized in the latter part of 1930, and I can now report that the committee has made considerable progress. The organization of the work is through eight Sub-Committees, on which the members of our Association are represented and occupy the chairmanship of two of these Sub-Committees.

The work consists of making revisions of the 1924 report, making such additions and rearrangement of material to present a more complete report and fulfill the requirements of today rather than that of eight years ago.

The progress of the committee-work was somewhat interrupted due to the great loss the committee suffered in the death of its Chairman, Professor W. A. Slater, who died in October of last year. Mr. Hollister has been acting as chairman since that time, and the next meeting of the committee will be held in June of this year at which time a permanent chairman will be elected, and the officers for the ensuing year elected.

I should like to impress on the members of the Association again that your representatives would greatly appreciate any suggestions, criticisms, or any other advice that you could give them in connection with the 1924 report.

The President:—Thank you, Mr. Richardson.

Chairman Meyer Hirschthal:—The next subject to be reported on is contained in Appendix E, page 653, Prevailing Methods and Practices of Lining and Relining Tunnels. It will be presented by Mr. G. F. Eberly, Chairman of the Sub-Committee.

Mr. G. F. Eberly (Baltimore & Ohio):—We have just started on this subject, and as a preliminary we thought it very suitable that we ascertain the prevailing methods

and practices of lining and relining tunnels and therefore sent out a questionnaire to all Class I railroads of the United States and Canada and the European roads.

We received 55 replies, representing 187,917 miles of road. Thirty roads reported experience, 11 no experience, and 14 no tunnels.

The first compilation is of interest, mileage of railroads and mileage of tunnels. In the United States and Canada there are 26 roads, representing 141,358 miles. You will note they have 1.39 miles of tunnel per 1000 miles of road, while for the European roads reporting, totaling 4, they have 18.54 miles of tunnel per 1000 miles of road, or 17.15 more miles of tunnel per 1000 miles of road in the European roads than in the American roads.

It is also interesting to note the table below, England, France and Switzerland, where in England they have 14.87 miles of tunnel per 1000 miles of road; in France, 14.63, and in Switzerland, 56.55. Therefore, it would seem that we should give due consideration to what they line their tunnels with over where they really have tunnels.

The Swiss use concrete blocks or concrete. The French use brick and stone. The English use Staffordshire blue-brindled brick. In America, the majority use concrete.

We feel we have developed a lot of very interesting information here which is a step to assist us in preparing specifications during the coming year for lining and relining tunnels. I will not take time to go into the details.

The President:—If there is no objection, the report will be so received.

Chairman Meyer Hirschthal:—The last subject to be reported on in the Masonry Committee's report—before I mention that, I want to say there was one other subject that we expected to have a report on this year, that of Expansion Joints, but the assignment was too late so it was not in shape to be prepared in a form that would be convenient to bring before the convention.

Subject (8) is contained in Appendix F, page 660, State of the Art of Repairing Deteriorating Concrete, and consists of tentative specifications for that purpose. Mr. A. C. Irwin, Chairman of that Sub-Committee, will present the report.

Mr. A. C. Irwin (Portland Cement Association):—The principal thing we desire, in connection with this report, is a critical reading of it and, following that reading, just as much unfavorable and unfriendly criticism as we can get.

The subject is rather a difficult one. A lot of different practices have grown up in repairing deteriorating concrete. There are new things coming along, new ideas. There are all sorts of special materials being proposed for use, special equipment that is being devised and is highly recommended, and so on, the merits or demerits of any of which I have nothing to say. No doubt something of value will come out of those efforts in the end.

It does not make any difference how far off the subject your criticism may seem to be, let the Committee judge that. If you are off the subject in your criticism, our thanks will be due, but the proper final deposit of your criticism will be found.

There is already in the Manual specification for repairing deteriorating concrete. It is proposed that these will replace those already in the Manual.

Since these are offered as tentative, with the expectation that they may be revised and will be revised next year and presented for adoption to replace material already in the Manual, all I can do is to present this as information.

The President:—The Chair hopes the membership will bear in mind Mr. Irwin's request, that he wants both friendly and unfriendly criticism, but at least help in getting the necessary right answer to this problem, and that you will take occasion to give this Committee all the help possible and suggestions that may appeal to them.

Mr. B. R. Leffler:—I just want to make a suggestion, and not take up too much time. On page 663 of this report of Mr. Irwin's, it says: "The surface of all new concrete shall be kept continuously damp for a period of seven days."

Now in concrete repair work, especially by the gunite method, the new concrete is of thin dimensions and is deposited with a minimum amount of water. It is necessary to cut the water down in order to make the gunite stay in place. That makes it more important to have the concrete, after it is in place, fed with water so it will cure..

Water on the outside of concrete is a good thing. Too much on the inside is bad. So I think the first paragraph of Section 9 might be strengthened a little bit by saying "continuously wet" instead of "damp". That word "damp" is a little too vague. There should be a sprinkling of water playing over the surface, not with violence but more like a gentle shower for about seven days. I would suggest that the Committee consider this feature.

Mr. A. C. Irwin:—We will be very glad to do so. Anything that can be done to strengthen the specification for curing of concrete will meet with the approval of the Committee. Any suggestion as to the proper wording of the specifications will be appreciated.

The point of curing gunite, I believe, has often been neglected. The reason for allowing laxity in curing gunite and requiring good curing for ordinary cast-in-place concrete is an anomaly to me. I think it is something that has been forgotten. Anything we can do to strengthen this, we will be glad to do.

Chairman Meyer Hirschthal:—This concludes our report.

The President:—Mr. Hirschthal, we are very much indebted to you and your Committee for your very splendid and thorough report. You are excused with our thanks (Applause).

DISCUSSION ON WATERPROOFING OF RAILWAY STRUCTURES

(For Report, see pp. 367–368)

Mr. J. A. Lahmer (Missouri Pacific):—This Committee was organized only during the past year and consequently we have very little for the action of the convention.

The first thing that seemed fitting was to agree on definitions of a few words and terms, and we are now recommending them for insertion in the Manual. They will be found on page 368 of Bulletin 342. They are as follows:

"WATERPROOFING.—The treatment of any material or structure to prevent the entrance or passage of water or other liquid under head.

"DAMPPROOFING.—The treatment of any material or structure to prevent the entrance or passage of water or other liquid not under head.

"IMPERVIOUSNESS.—The quality of being completely resistant to penetration by water or other liquid.

"INTEGRAL WATERPROOFING.—The process by which a material is forced into the pores or cracks or to the exterior or pressure side of a structure for the purpose of making it watertight.

"MEMBRANE WATERPROOFING.—The application of alternate layers of fabric or felt, and bitumen, to form a covering on a surface for the purpose of preventing the entrance of water or other liquid under head.

"SURFACE COATING.—The application of a liquid by brush or spray for the purpose of waterproofing or dampproofing.

"METALLIC WATERPROOFING.—The application to a surface of a mixture of a metal and a reagent, the chemical reactions of which tend to fill the pores."

These definitions are submitted for insertion in the Manual, and I so recommend.

The President:—You have heard the motion, gentlemen. Is there any discussion?

(The motion was put to vote and carried.)

Chairman J. A. Lahmer:—There were three other subjects undertaken by the Committee, and on each of them we simply report progress and ask that they be reassigned. They are as follows: When to Waterproof or Dampproof and Methods to be Used; Waterproofing and Dampproofing as Applied to Existing Railway Structures; Specifications for Membrane Waterproofing of Concrete.

We have collected a considerable amount of information on the last subject, and have given the matter considerable thought and discussion, and hope to present specifications at the next convention.

Attention is called to an error in our report as printed on page 367 of Bulletin 342. The word "bridges" at end of first sentence of Subject (4) should be "buildings."

The President:—If there is no objection, it will be so received.

This is the first report of this Committee, and I think they have made quite some progress, considering the short time they have had to work. You are excused with our thanks (Applause).

DISCUSSION ON RECORDS AND ACCOUNTS

(For Report, see pp. 587–620)

Mr. C. C. Haire (Illinois Central):—The Committee's report is found in Bulletin 344, page 587. We have 15 assignments covering various accounting, valuation and statistical subjects.

On the first subject, Revision of Manual, the Committee has only a progress report, as we believe it is desirable to defer making a definite report until several vital questions in our field become more solidified, such as proposed reduction in valuation requirements, new classification of accounts, and the depreciation accounting matter.

With these questions becoming more settled, there will be needed a substantial revision of certain material in the Manual. We have only a progress report on the subject.

The next assignment is the Bibliography subject, which is reported under Appendix A. This is a continuation of what has been done before, and the Committee calls attention to certain outstanding books and articles that have been published during the year. This is given as information.

The President:—It will be received with appreciation.

Chairman C. C. Haire:—Our next subject is likewise information, although we published a brief progress report to show what we are doing.

The next subject the Committee has is on page 591, under Appendix C. The Committee has a report on methods and forms for maintaining a record of railway, highway and private grade crossings, collaborating with Committee IX—Grade Crossings. Mr. E. S. Butler, in the absence of Mr. James, Chairman of the Sub-Committee, will present the report.

Mr. E. S. Butler (Kansas City Southern):—This Sub-Committee is bringing in three forms which it will recommend be included in the Manual. In working up these forms, some points of interest have developed that I will outline briefly.

In working up the forms for recording grade crossings, the Committee canvassed railroads and found that in 40 states no annual reports other than those reported to state commissions, showing information that is reported annually to the Interstate Commerce Commission, are required, and it found that there is a steady net increase in the number of grade crossings. In 1926 this increase was 195; in 1927, 245; in 1928, 270;

and in 1929, 321. That is a net, in spite of the fact that we are constantly eliminating grade crossings.

The Committee also found that there are 242,809 highway grade crossings on Class I railways. That is an average of about one per each mile of road.

The forms which are found on pages 592 and 593 of Bulletin 344 provide a method of recording systematically the information required by I. C. C., state commissions, and by the Bureau of Railway Economics, and does not go much beyond the information required by those bodies. These two forms are recommended by the Committee for inclusion in the Manual, and I will make a motion to that effect.

The President:—Gentlemen, you have heard the motion. Is there any discussion?

(The motion was put to vote and carried.)

Mr. E. S. Butler:—The form found on page 594 of the same Bulletin was discussed yesterday in connection with the report of the Committee on Grade Crossings, and I think was adopted for inclusion in the Manual in about the form that this Committee has developed it. I will make a motion that this form be included in the Manual.

The President:—Would that not be a duplication?

Mr. E. S. Butler:—That is a question for the convention to decide. This subject was assigned in a little different form to the two Committees by the Committee on Outline of Work. At least that is my understanding.

The President:—Is there any discussion on that feature?

Mr. F. L. Nicholson (Norfolk Southern):—I would like to ask if that is a duplication.

Mr. E. S. Butler:—Very much so.

Mr. F. L. Nicholson:—Why include it in the Manual?

Mr. E. S. Butler:—It is an assignment by the Committee on Outline of Work of the Board of Direction.

Mr. F. L. Nicholson:—I do not see any advantage in having duplication of work in the Manual.

Mr. E. S. Butler:—I agree with that, but we are just carrying out instructions.

The President:—Would it be satisfactory to receive this as information and leave it to the Board of Direction to decide whether this should be duplicated in the Manual?

Mr. E. S. Butler:—The Chairman says that is satisfactory to the Committee.

The President:—It will be so disposed of, if that is satisfactory to the convention.

Chairman C. C. Haire:—The next subject the Committee has on its assignment is Bridge Inspection Report Forms, collaborating with four different Committees.

I will call your attention to the form that has been before Committee XI for about three years. We thought we had made a final report last year, but have now discovered certain objections and will need another year to iron those out. If there are no objections, we will carry the assignment another year.

The President:—If there are no objections, it will be so received.

Chairman C. C. Haire:—The next assignment the Committee has is under Group C, Maintenance of Way reports and records: (C–1) statistical requirements of operating, accounting and other departments with respect to maintenance of way and structures, collaborating with appropriate Committees. This is also a progress report. We have under Appendix E certain information as to progress. It is quite a broad subject and almost endless in scope. We hope to submit more data on records and forms next year.

The President:—Unless I hear objection, this will be so received.

Chairman C. C. Haire:—The next subject the Committee has, (C–2), covers system of reports and records required to budget and control maintenance of way expenses.

The Committee reports progress on this assignment. Considerable data have been collected. This is another subject where it seemed desirable to defer final action until the new classification of accounts is available during the coming year, as any system of budgeting should be based on an accounting system that is required of us. Therefore, we decided to defer any action until we know where we are headed.

The President:—We will consider this satisfactory, unless we hear objection.

Chairman C. C. Haire:—The next subject the Committee has is under (C–3), Forms used by Railway Water Service Departments, and will be submitted by Mr. D. C. Teal, Chairman of the Sub-Committee.

Mr. D. C. Teal (Chesapeake & Ohio):—The report of Sub-Committee (C–3) is shown in Bulletin 344, page 598. The assignment is: Study and Report on Forms used by Railway Water Service Departments, collaborating with Committee XIII—Water Service and Sanitation.

"The study of forms now in common use by railway water service departments resulted in the following general classification of reports and records:

"(1) Monthly and yearly report of cost of producing and treating water.
"(2) Pumper's and treating plant operator's reports.
"(3) Water station record.
"(4) Geological record of deep wells."

A form covering the first general class of reports was presented to the Association last year, and was recommended as the permanent cost of water production record suitable for present-day water service requirements, to be kept in the headquarters of the officer in charge of water supply.

This year the Sub-Committee has taken up the study of the second general class of reports, or pumper's and treating plant operator's reports. Consideration was first given to the possibility of combining the pumper's report of water station operation with the water treatment report. Further investigation, however, proved that such a form would be unsatisfactory, as some railroads have no water treating plants and others have relatively few of their stations equipped with treating facilities. The investigation also developed that most railroads prefer to handle their water station operation entirely separately from their treatment.

So for this year's report the Sub-Committee presents a form to be originated by the pumper covering monthly report of water station operation, and is recommended for the daily recording and monthly reporting of water production and consumption and is to furnish the underlying information from which to compile the permanent costs of water production records, as well as to furnish other information necessary for the close check of water station performance. This form has the approval of Committee XIII—Water Service and Sanitation.

The Sub-Committee presents the report as information and progress with the understanding that the form shown is to be recommended for inclusion in the Manual at a later date, along with the form for costs of water production that was presented last year, and with the water supply forms that have not yet been developed. The assignment is to be continued.

The President:—Unless I hear objection, we will receive the report with appreciation.

Chairman C. C. Haire:—Under Appendix G, Subject (E–I), we have our perennial report on the valuation question, that is, keeping up-to-date valuations. Mr. Bertenshaw, Chairman of the Sub-Committee, will present the report.

Mr. B. A. Bertenshaw (Cleveland, Cincinnati, Chicago & St. Louis):—The report of this Sub-Committee may be found in Bulletin 344, pages 600 to 605. The report is in two sections. The first part pertains to the forms, and this year the Committee's whole endeavor was on the revision of forms previously submitted.

Exhibit 1–2 (Exhibit 2 is a continuation sheet for Exhibit 1) is a form for recording a list of sidetracks, and is a revision of form in the Manual at page 717. The form now presented is reduced to the standard size, 11 $\times$ 17 inches, and is very much simplified.

Exhibit 3, found on page 603, is a Register of Authorities for Expenditures form. This form is also a revision of the one in the Manual, and it can be found on page 723. This has likewise been reduced to the standard 11 $\times$ 17 inch size. A number of columns have been eliminated, and the entire form simplified.

The last form, Exhibit 4, is found on page 603, Detailed Estimate Sheet. On this form the Committee has eliminated all ruling and printing in the body so as to permit of more economy in space and more flexibility in recording the information.

The aim of the Committee all the way through has been to simplify these forms so as to have forms which are simple, easy, and inexpensive to maintain, and yet record all the useful information. The forms are presented at this time for information only.

The President:—Unless I hear objection, we will so handle it.

Mr. B. A. Bertenshaw:—The second part of the report has to do with a study made by the Sub-Committee as to possible economies that might be effected in valuation reports by eliminating certain records, and particularly in an effort to find some simplified method of recording small units of relatively small importance.

A study was made chiefly on Account 10—Other Track Material, to see if numerous items could be typed or grouped and thus reduce the large number of pricing units. Six methods were studied, and these are listed on page 605. After testing out these six methods, the Committee concluded it was impractical to recommend any one of the six due to such a wide variation in kinds of material on the different roads, and different valuation sections of the same road, and it was their idea that any railroad wishing to use any one of these methods should first test it out sufficiently to see that it is adapted to that particular road.

The President:—Unless we hear objection, the report will be received as information.

Chairman C. C. Haire:—Our second subject under valuation is methods and forms for maintaining a record of changes in jointly owned interlocking plants. Mr. A. P. Weymouth, Chairman of the Sub-Committee, will present the report.

Mr. A. P. Weymouth (Pennsylvania):—Report of this Sub-Committee appears on pages 605 and 606 of Bulletin 344, and is submitted at this time as a final report dealing with methods and forms for maintaining a record of changes in jointly owned interlocking plants.

Last year the Committee submitted a progress report, and this year has continued its study of the subject, collaborating with Committee X—Signals and Interlocking. Of the various methods outlined in last year's report, the Committee feels that the "investment basis" for establishing ownership is preferable. This method appears to be logical and in accord with other practices, as brought out in the report.

We have prepared a form which accompanies this report, Exhibit 1, as printed on page 607 of the Bulletin, to serve as a guide in maintaining the record of changes from year to year, and to determine the different percentages of joint ownership.

The collaborating Committee, Committee X—Signals and Interlocking, has approved this report.

The Committee submits this report as information, and recommends that the subject be discontinued.

The President:—Unless there is objection, it will be so received, Mr. Weymouth.

Chairman C. C. Haire:—The third subject under the general valuation subject is methods used in recapture proceedings. Mr. C. J. Geyer, in the absence of Mr. Charles Silliman, will present the report of the Sub-Committee.

Mr. C. J. Geyer (Chesapeake & Ohio):—Report of the Sub-Committee is in Bulletin 344 beginning on page 608. It is a review of recapture matters in general, and a brief of the recapture proceedings in the case of the Richmond, Fredericksburg & Potomac Railroad and the Norfolk & Western, as far as the latter case had progressed when this report was made late in the fall of 1931.

There is also a reference to Depreciation Order No. 15100, to the effect that on July 28, 1931, the Commission issued its decision and order that depreciation accounting in the road and equipment accounts should become effective as of January 1, 1933, in accordance with Order No. 15100.

It is recommended that this be received as a progress report and the subject continued, and we hope it will not be necessary to continue it very much longer.

The President:—Unless there is objection, it will be so handled.

Chairman C. C. Haire:—Under our next general group we have two subjects, revision of the accounting classification, and Depreciation Order, Docket No. 15100. These are related matters and we have coupled them together here. I will ask Mr. W. R. Kettenring to give you the latest development.

Mr. W. R. Kettenring (Chicago & Northwestern):—The final report on depreciation charges of steam railway companies was served on the railway companies in the early part of September, 1931. Under this order the roads are required to file with the Commission, not later than September 1, 1932, estimates of the percentage rates applicable to the ledger values of their properties, and are required to inaugurate depreciation accounting effective January 1, 1933.

In view of the delay of the Commission in issuing the revised classification of accounts, with which the depreciation order is inseparably interlocked, and anticipating the efforts of the railway executives to postpone the effective date of the order, the Committee has not prepared for submission, plans for the practical application of the order to the railway accounts. It has, instead, brought down to date the previous report which was contained in Vol. 30 of the Proceedings. This report is submitted merely as information.

The President:—Unless there is objection, it will be so received, with appreciation.

Mr. W. R. Kettenring:—As mentioned, the accounting classification has not been received by the railways, and until this has been received there is little that the Committee can do on the subject.

The President:—This will likewise be so received, unless there is objection.

Chairman C. C. Haire:—The third subject under our general assignment is methods for avoiding duplication of effort and for simplifying and coordinating work under the requirements of the Interstate Commerce Commission, with respect to accounting, valuation and depreciation. The Committee has a progress report, and I will ask Mr. Sharood, Chairman of the Sub-Committee, to present it.

Mr. F. C. Sharood (Northern Pacific):—Report of this Sub-Committee will be found on page 618, Bulletin 344.

In presenting this report, the Committee regrets that it cannot go beyond discussion of the fundamentals which underlie this subject. Earnest effort was made to prepare and submit conclusions with recommendations for future action, but, as we have attempted to show in the report, the lack of harmony among the carriers has prevented us from securing a united front. The Committee finds itself in about the same situation as the Allies did in 1915 and 1916. While we are not at war, several carrier organizations are working with the Commission, each on a different subject or group of subjects, and each one striving to carry out its own views without much knowledge of or regard for the views of the others.

As with the Allies, nothing can be accomplished without a supreme command clothed with authority to act, which can meet with the Commission and work out a plan of coordination and simplification which will be to mutual advantage. In the opinion of this Committee, the expenses of the carriers, in complying with the orders of the various Bureaus of the Commission, warrant the appointment of such a supreme command. It is not possible to state with any degree of exactness the amount of these expenditures for the country as a whole, but let us assume that each Class I carrier in the country spends $300,000 in the year for collecting, tabulating and reporting this data. That would be $3,000,000 in ten years. If a similar expenditure were contemplated for grade revisions, construction of additional main track, elimination of grade crossings, or the purchase of new equipment, the operating and engineering officers of the carriers would devote sufficient time to a consideration of all phases of these projects to satisfy themselves that the money was wisely spent. Is there any difference between money spent for this latter class of projects and the dollar that is spent collecting data and maintaining records?

The Committee submits its report and respectfully requests that you gentlemen give this latter question earnest consideration.

The President:—Gentlemen, I hope you will give this consideration and give the Committee the benefit of your views.

Unless there is objection, the report will be received as information.

Chairman C. C. Haire:—The Committee can only report progress on this subject as it is somewhat similar to the other matters affected by pending revisions of the accounting classification. However, Mr. Sharood is also Chairman of this Sub-Committee and I will ask him to make a few remarks on the subject.

Mr. F. C. Sharood:—The practice on the part of both carriers and Commission in requiring evidence with respect to costs, both of maintenance operation and related subjects in rate cases, has grown to the extent that this Committee felt some uniform practice would perhaps be advisable in order to prevent conflicting theories being injected into various cases, that conflict in theories being used to the detriment of the carriers.

We attempted last year to work out something to report on that particular subject. Again, an attempt was made this year, but we find that the contemplated changes in the accounting classification, the issuance of the depreciation order which radically changes the method of accounting for maintenance of way and structure expense, and also a slight change in the policy of the Commission with respect to the fixing of rates and the bases used in determining those rates, has made it quite essential that this subject be deferred until the accounting classification and depreciation order are definitely fixed and determined by the Commission.

Therefore, the Committee asks your indulgence, and that it be permitted to continue this subject for another year.

The President:—It will be so handled, unless objected to.

Chairman C. C. Haire:—That concludes the Committee's report.

The President:—We are appreciative of your splendid report and the large amount of work that has been done in connection with the report. We want to express our appreciation to you and your Sub-Chairmen (Applause).

DISCUSSION ON BALLAST

(For Report, see pp. 349–366)

Mr. A. P. Crosley (Reading):—Report of Committee II—Ballast, is found in Bulletin 342, pages 349 to 366 inclusive.

The first subject is Revision of Manual. Mr. M. I. Dunn of the Chesapeake & Ohio is Chairman of the Sub-Committee and will present the report.

Mr. M. I. Dunn (Chesapeake & Ohio):—This Sub-Committee has been considering several subjects dealing with the revision of the Manual. Special attention has been given to the ballast sections now shown in the Manual, and considerable data has been accumulated, but the work has not progressed sufficiently to warrant making any recommendations at this time. The report is submitted as information only.

Chairman A. P. Crosley:—The report on the second subject, Specifications for Prepared Gravel Ballast, including best method of testing for hardness, abrasion and resistance to weathering, will be found in Appendix A, page 350. The report will be presented by Professor C. B. Stanton, Chairman of the Sub-Committee.

Prof. C. B. Stanton (Carnegie Institute of Technology):—The principal work of the Sub-Committee has consisted of the collection of information to assist in the formulation of specification clauses to cover factors such as resistance to abrasion and resistance to weathering. A questionnaire was sent to the railroads to determine the extent to which the present specifications are being used, also to guide the Committee in the further study of this subject. Many replies were received and the Committee will give the Association the benefit of this information in next year's report.

In the study of the first problem, detailed tests have been conducted to determine the physical characteristics of samples of gravel ballast. This work has been carried out by W. L. Foster, of the Iowa State College, and Stanton Walker, of the National Sand and Gravel Association. To supplement the laboratory investigations, a request was sent to railroad engineers familiar with the specific gravels which had been tested, asking them for their experience and the action of the gravels under field conditions. The replies received are very valuable and represent considerable thought on the part of those reporting. The Committee is trying to correlate the field data with the laboratory data. The Committee desires an opportunity of studying this information further before drawing conclusions.

The Committee is continuing its study in an attempt to make definite recommendations for clauses covering factors not included in the present specifications. The tentative clause on deleterious substances is found on page 353, and the Committee would welcome any suggestions. The present specifications contain no limitations on hardness or resistance to abrasion of ballast. The proposed test method has been generally agreed upon but the limits should receive further study, and this the Committee is following up.

On page 351 are given tables covering five additional samples of gravel which have been tested in the research laboratory of the National Sand and Gravel Association. The results of the tests on the previous 16 samples are shown in Volume 31 of the Proceedings, pages 764 and 765. On page 352 is given the results of accelerated soundness tests on the 25 samples. It is proposed to attempt to correlate this laboratory data with field experience in an attempt to fix specification limits.

Mr. Chairman, this report is submitted as information.

(Past-President Louis Yager in the Chair.)

Past-President Louis Yager:—This is a very interesting outline as presented here for you. Are there any questions before we pass on? We will receive this as information.

Chairman A. P. Crosley:—In the report just submitted mention has been made of two things which in the ordinary course of procedure might be overlooked. The first is the questionnaires which were sent out. There is an old saying that "It is an ill wind that blows no one any good". This applies with reference to the questionnaires for the replies received were not only from a great many railroads but also represented considerable thought and time on the part of those replying. Possibly the dull times gave more time to answer the questions. The Committee appreciates the interest taken and wishes to take this opportunity of thanking all who have cooperated with them.

The second feature is the work done by various men on the Committee and the facilities with which they are associated. Professor Stanton of Carnegie Institute of Technology, Professor Foster of Iowa State College, Mr. Stanton Walker of the Research Laboratory of the National Sand & Gravel Association and Mr. A. T. Goldbeck of the Research Laboratory of the National Crushed Stone Association have done considerable work for the Committee.

Mr. J. M. Podmore (New York Central):—At the 1931 convention the Association approved revised specifications. In presenting these specifications to the convention, your Committee called attention to the fact that there was considerable doubt as to the factor for cementing value as appeared in the 1929 Manual. Since then laboratory tests have been conducted on various stones to determine a factor for cementing value. After considerable study, the Committee is suggesting that the cementing value, as appearing in Sections 6 and 24 of the specifications, be omitted for reasons given at the bottom of page 354 and the top of page 355. The Committee recommends that these changes be made.

Past-President Louis Yager:—Your change in the Manual is the elimination of that part now?

Chairman A. P. Crosley:—Elimination of Sections 6 and 24.

Past-President Louis Yager:—The recommendation is with respect to the elimination of Sections 6 and 24 in the present Manual. Is there any discussion?

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—The specifications that are now in the Manual in which cementing value is given, were the outgrowth of a study of government specifications for highway pavement stone some years ago when a good many macadam pavements were still in use. The government specifications required a high cementing value for pavement stone.

There was a tendency at that time to accept those same specifications for railway ballast when, in fact, railway ballast really needs as low a cementing value as possible. I will say that it is undoubtedly true that some ballasts which may have a high cementing value but very little abrasive condition may be good ballasts but, on the other hand, we may find some stones which have a large abrasive factor and also a cementing value. The two taken together should condemn that stone as good ballast stone.

It appears to me that it is very desirable to have the provision for cementing value remain in the specifications for ballast stone.

Chairman A. P. Crosley:—The reasons for recommending this are given on pages 354 and 355. Your Committee knows that in many cases the cementing value is not used. We know of firms that test railroad ballast for railroads that disregard this clause entirely, among other things, for the reason given, namely, that the stone that will abrade will have some cementing value but one that does not abrade the cementing test would be of little value. When you get down to it, local conditions will govern the stone used due principally to source of supply.

Another feature is that there are very few laboratories that are equipped to make the cementing test as called for in the present specifications.

The Committee has no serious objection to retaining it, but just felt it was more or less superfluous in view of the fact that it was not being used, or the roads apparently did not consider it of sufficient importance to insist upon having it carried out.

Mr. F. M. Thomson (Missouri–Kansas–Texas Lines):—We find that the cementing factor is to be considered materially in our ballast secured in Missouri, and I think that should remain in the specifications or probably be revised, dependent upon the amount of abrasion of the material, if you want to do that, but some attention should be given to the cementing value.

Past-President Louis Yager:—Mr. Ray, have you any comments to make?

Mr. G. J. Ray (Delaware, Lackawanna & Western):—I think not. We have never had any experience with cementing gravel ballast. If we had such ballast, I do not think we would use it. In a part of the country where cementing gravel ballast can be used to advantage, I see no reason why it should not be used. I see no objection to leaving it in the specifications.

Past-President Louis Yager:—Pardon me, Mr. Ray, this deals with stone, and I called on you for your remarks for the reason that you use a good grade of stone ballast. I take it you are supporting the Committee in their recommendations.

Mr. G. J. Ray:—Yes, sir.

Mr. C. W. Baldridge:—This is a specification which is of little value or of little consequence in the East where there is an abundance of hard, excellent ballast stone. Through the Middle West there is not such a good supply of good ballast stone, and throughout the Middle West the cementing value together with the abrasive condition of stone should be taken into consideration.

I think Mr. Thomson's suggestion is a good one, that the Committee take this under consideration and revise cementing value and abrasive condition to go together, because it is important in a large part of the country.

Past-President Louis Yager:—Are there any other comments from those similarly situated who have to use a stone ballast that does have cementing qualities?

Are you ready for the question? The question is on the recommendation that Sections 6 and 24, dealing with cementing value, be removed from the Manual.

(The motion was put to vote and lost.)

Mr. J. M. Podmore:—The Committee is also recommending that Section 9 be changed to read as follows: "Each stratum or portion of the quarry containing a variation in quality of stone, shall be tested separately and not averaged with any other stratum or portion of the quarry." As sometimes occurs, variations will be found in the same quarry and it is essential that these strata be tested individually to determine their suitability for ballast purposes. The Committee moves that the Manual be changed.

Past-President Louis Yager:—It has been moved and seconded that Section 9 be modified as has been read to you. Is there any discussion?

(The motion was put to vote and carried.)

Mr. J. M. Podmore:—The Committee recommends that Section 10, Averaging, be modified. The present form is given in tabular form and calls for five tests. It is felt that the averaging of three tests will give equally satisfactory results and adequately protect the consumer. The new section to read as follows: "For obtaining the values for physical tests, the average results from three samples representing a given stratum or portion of the quarry shall be taken." The Committee recommends that this change be adopted.

Past-President Louis Yager:—It has been moved and seconded that the number of samples be reduced from 5 to 3 as read. Is there any discussion?

(The motion was put to vote and carried.)

Mr. J. M. Podmore:—There has been some very interesting work conducted in the laboratory on the stability of ballast as affected by gradation and sizes. The Committee is not ready to submit a report at this time, but hopes to have some figures for a future report.

Chairman A. P. Crosley:—The next subject, Shrinkage of Ballast, is found in Appendix C on pages 355 to 359 inclusive, and the report will be presented by Mr. Colladay, Chairman of the Sub-Committee.

Before Mr. Collady presents the report, the Committee wishes to take this opportunity of thanking the railroads that established test sections. Without their cooperation, the Committee would have been unable to carry out their assignment, and to these roads the Committee is deeply indebted.

Mr. Colladay is not here. Mr. Woerner will present the report.

Mr. A. H. Woerner (Baltimore & Ohio):—The report on Shrinkage of Ballast starts at the bottom of page 355. This subject has been before the convention for a number of years and there have been reports on it from time to time.

There has been more or less confusion as to just what is meant by shrinkage of ballast, and in order to clear up this confusion, we have quoted in heavy type, starting at the middle of page 356, some information obtained from hearings before the I.C.C., the first paragraph of which describes what was considered as shrinkage of ballast.

With this in mind, the Committee prepared specifications for establishing test sections in 1929. These specifications were submitted to the convention, and then the Committee got busy to establish test sections. The information which we have from these test sections is shown on page 358. You will note from an examination of this table there have been several test sections in service now for three years, and the information contained is quite startling.

The Committee believes it has done all it can do unless the railroads are willing to establish additional test sections.

Past-President Louis Yager:—This is to be received as information, and the Committee recommends that the subject be discontinued. If you will recall, this subject has been up for some time, and the statement was made that nothing could be done about it, that is, to differentiate between the different kinds of shrinkage.

It seems to some of us that the Committee have made a good start and they have brought in some very interesting information. This recommendation of the Committee, with respect to the future disposition of the subject, will be taken in hand by the Committee on Outline of Work.

Chairman A. P. Crosley:—The next subject, comparative costs of maintaining track on various kinds of ballast, will be found in Appendix D on pages 359 to 363 inclusive. The report will be presented by Mr. Daniel Hubbard, Chairman of the Sub-Committee.

Mr. Daniel Hubbard (Chesapeake & Ohio):—At the start of this work, a questionnaire was sent out to practically all Class I railroads to find out, if it was possible, what costs were being kept with reference to gravel and stone ballast. We were rather disappointed to find that only one railroad was handling such actual figures.

Tables on pages 360 and 361 give the data on stone ballast for the years 1927 to 1930 inclusive, and the tables on pages 362 and 363 give the data for gravel ballast for the same period. On these two sections, the physical characteristics, number of trains, and tonnage are identical and, therefore, the comparison should be of considerable value.

The Committee desires to call attention to the fact that it will not be able to give figures for track on other types of ballast unless it is possible for some railroads to come through with the necessary data. The subject should be given further consideration, and additional sections of track will be worked up to check against this report.

Past-President Louis Yager:—You will recall this is a subject on which information has been solicited for a good many years. We are gratified to find that the Committee has made at least a beginning.

Chairman A. P. Crosley:—The last subject, proper depth and kind of sub-ballast, is found in Appendix E on pages 364 to 366 inclusive. The report is submitted as information only and will be continued for additional study and further report. The Committee would welcome criticisms on this report as well as on the other assignments.

This completes the report of the Ballast Committee.

Past-President Louis Yager:—The Committee has done a very fine piece of work. They are to be congratulated on the work they have brought to you, and they are now excused with the thanks of the Association (Applause).

DISCUSSION ON TIES

(For Report, see pp. 475–495)

(Past-President Louis Yager in the Chair.)

Mr. John Foley (Pennsylvania):—You will find the report on pages 475 to 495.

There are no recommendations for changes in the Manual. All the material is submitted as information.

Extent of Adherence to Standard Tie Specifications will be found in Appendix A. Once more, the Committee on Ties feels able to report that there has been no grievous laxity in the inspection of ties, taken as a whole. Of course, there are railroads which still continue careless, but their number is lessening steadily. During the year there was one railroad, with 14,000 miles or more of track, largely west of the Mississippi River, that moved over to the standard specifications. We are reliably informed that another railroad, with extensive trackage, will adopt the standard specifications before the Proceedings are printed.

The suggestion made by the Purchases and Stores Division that the grouping of ties be made on the basis of price rather than their serviceability was considered by the Committee and found impractical, the reasons for the decision being given in the report.

The data on Substitute Ties in Appendix B are merely tabulations of the experiments with the types of ties reported, and no comment is necessary. We will be glad to have suggestions from the membership as to additions which might be made.

In the matter of Tie Renewal Averages per Mile Maintained, we again present the figures derived from the reports to the Interstate Commerce Commission, and plan next year to provide a five-year average by consolidating the data that have been presented the last four years. The Committee has received no suggestions as to additions or eliminations, and assumes that the information presented is satisfactory to the Association.

The report on Economics of Use of 8½-foot and 9-foot Ties as Compared with 8-foot Ties will be presented by the Chairman of the Sub-Committee, Mr. J. E. King.

Mr. J. E. King (Chesapeake & Ohio):—This is the first year's assignment of this subject, and your Committee has made no attempt to submit a comprehensive or conclusive report. The report is found on pages 492 to 494 of Bulletin 343.

On page 495 is shown a table which indicates the practices of 38 railroads with respect to the use of 8-foot 6-inch ties. A questionnaire was sent to 57 railroads to determine what their practices were; the 38 roads responding represent all sections of the United States and Canada, presenting a reasonably accurate view of the situation.

On page 492 we quote from responses of two railroads. These responses show some of the reasons why these railroads have gone to the use of ties longer than 8 feet.

On page 493 is shown a report from one railroad indicating a definite reduction in cost of maintenance following the adoption of ties longer than 8 feet.

Your Committee is confident that further data can be secured which will permit establishing reasonably correct limits within which the different lengths and sizes of ties may be used most economically.

We recommend that this report be received as information.

Past-President Louis Yager:—Are there any questions?

This is a very important economic subject and we are glad to learn the favorable beginning that has been made. The Committee promises to amplify the subject later.

If there are no objections, we will receive this as information.

Chairman John Foley:—Methods of Dating Cross-Ties is covered in Appendix E, and such comments as the report requires will be made by Mr. C. W. Greene, Chairman.

Mr. C. W. Greene (New York Central):—Forty-one replies to 70 questionnaires sent to railways in the United States and Canada may be summarized as follows:

Before I read the miles of maintained track, I wish to say there was a typographical error in the report of the Sub-Committee which resulted in an error in the miles shown on Bulletin 343, page 494. The two right-hand figures for each item should be eliminated.

	Number of Railroads	*Miles of Maintained Tracks Occupied by Cross-Ties*
Using dating nails on all ties	24	118,020
Using dating nails on ties in test sections only	2	15,260
Using dating nails in treated ties only	1	1,373
Branding dates on all ties	4	4,813
Stamping dates on all ties	1	10,673
Using no nails nor brands of any kind	9	28,684

Fourteen railways are placing dating nails on ties, inside rails (not centered).

Six railways are placing dating nails on ties inside rails (centered on tie).

Two railways are placing dating nails on ties outside rails, various locations.

One railway has no definite location for dating nails.

Twenty-four railways are placing dating nails after installation of ties in track.

Eight railways are placing dating nails before installation of ties in track.

This is done at tie treating plants, generally.

Sixteen railways are using dating nails manufactured according to A.R.E.A. specifications.

Eight railways are using dating nails under various specifications.

All branding and stamping of ties is done on the ends of the ties.

A general practice of branding dates on ends of ties in addition to use of dating nails is apparent where adzing and boring machines are in use.

Chairman John Foley:—That concludes the work of the Committee on Ties, Mr. Chairman.

Past-President Louis Yager:—This Committee is one of the few of our Association that is engaged in policing the specifications which we have adopted, and I think you will agree with me they have had some very satisfactory results from their efforts in this direction.

The Committee is now excused with the thanks of the Association (Applause).

DISCUSSION ON WOOD PRESERVATION

(For Report, see pp. 517–554)

Mr. F. C. Shepherd (Boston & Maine):—The report of Committee XVIII—Wood Preservation, is found on page 517 of Bulletin 344.

Appendix A, Revision of Manual, is shown on page 518. This report will be discussed by Mr. E. B. Fulks.

Mr. E. B. Fulks (American Creosoting Company):—The Committee on Revision of the Manual has two slight changes which are shown on pages 518 and 519 of the Bulletin. They both have to do with methods of testing creosote.

The first one is simply a more accurate description of the crucible which is used for that purpose, and the recommendation of the Committee is that the present description, as shown in the Manual of 1929 on page 1308, be withdrawn and instead there be substituted the following:

"A platinum crucible shall be used, with tightly fitting cover of the inverted or capsule type having a depth of about 1 cm., provided with a hole 2 mm. in diameter at its center. The crucible shall have a capacity of 25 to 30 c.c. and with cover shall weigh 25 to 30 grams."

This simply describes the instrument more accurately. The other was rather a loose description. The Committee moves the adoption of this revision.

The President:—The matter is before you, gentlemen. Is there any discussion?

(The motion was regularly seconded, put to vote and carried.)

Mr. E. B. Fulks:—The Committee recommends that the specifications for "Specific Gravity of Fractions" be withdrawn and that there be substituted therefor the pycnometer method which is used everywhere for the determination of the specific gravity of liquids. The description of the method as printed, is rather long, but is essentially an accurate description of the apparatus and the method of procedure.

The President:—You have the matter before you, gentlemen. Is there any discussion?

(The motion was put to vote and carried.)

Mr. E. B. Fulks:—Since this report has been made, the work which has been going on for several years in cooperation with other associations at the Bureau of Standards for preparing accurate tables for volume and specific gravity corrections has been completed, but it came to us too late to get into the report this year, and consequently we are not offering it. But it has been adopted and has been presented to the Wood Preservers Association. It will be in the procedure of the American Society for Testing Materials, and we will offer it next year.

The President:—It will be so received, unless objected to.

Chairman F. C. Shepherd:—On page 519, under Appendix B, is shown report of the Sub-Committee on Service Test Records for Treated Ties. This report carries on the table of tie renewals per mile on various railroads, and also reports of special test tracks on various railroads. This report is offered as information.

The President:—It will be so received unless objections are heard.

Chairman F. C. Shepherd:—On page 535, under Appendix C, is given the report on Piling Used for Marine Construction, this being a continuing report on the present condition of long-time test pieces. This report is offered as information.

The President:—Unless I hear objection, it will be so received.

Chairman F. C. Shepherd:—On page 545, under Appendix D, is given the report on Destruction by Termite and possible ways of prevention. This is a continuing report offered for information.

The President:—Unless I hear objection, it will be so received.

Chairman F. C. Shepherd:—On page 545, under Appendix D, is given the report on Destruction by Termite and possible ways of prevention. This is a continuing report offered for information.

The President:—It will be so received, unless objected to.

Chairman F. C. Shepherd:—On page 547, under Appendix E, is given the report on Loss of Preservative in Treated Ties in Track due to repeated use of oil burning weed destroyers. This is a continuing report presented by the Committee. Their work is not completed. They have a conclusion for your information on page 549. This report is offered for information.

The President:—Unless I hear objection, it will be so received.

Mr. R. C. Bardwell (Chesapeake & Ohio):—This report on the loss of preservative in treated ties from operation of weed burner is of special interest in connection with the development of some suitable method for determining such loss or damage to treated timber.

In looking over this Committee's report it is noted that the Committee reached the conclusion, from results of experiments described, that little actual loss of preservative may be expected from operation of weed burning machines, if properly operated.

It is further noted that in 18 out of 21 comparative cases of loss in weight in burned and unburned test specimens, as outlined on page 548, they show greater loss where the weed burner *had not* been used than where the weed burner *had* been used. This high percentage indicates that there is either something wrong with the method, or that burning treated ties about 1½ seconds occasionally is a good thing for the ties.

I think this subject should be given special study with a view of determining whether this method is applicable for determining loss or damage to treated ties in track.

The President:—Do you accept that suggestion?

Chairman F. C. Shepherd:—Yes, sir.

The President:—The Committee accepts that suggestion.

Chairman F. C. Shepherd:—On page 549, under Appendix F, is given the report on Incising of Forest Products Material. This is the first report of this Committee and is offered to your body for information with the expectation that the subject will be continued.

The President:—Unless there are objections, it will be so received.

Chairman F. C. Shepherd:—On page 552, under Appendix G, is given report on extent, if any, to which decay is permissible in ties for treatment, the various forms of decay and the methods of detecting infection and decay. This report is offered as information, with the request that the Committee be discharged from any further consideration of the subject.

The President:—The Committee on Outline of Work will take notice of this recommendation and decide whether or not it should be dropped.

Chairman F. C. Shepherd:—We have no report this year (it was late coming in) from our Sub-Committee on mixture treatment, but we have a short report that has been prepared since the publication which we feel should be read into the records, as it may not be of particular value another year and should be used this year. I am going to ask Mr. G. C. Stephenson, Chairman of that Sub-Committee, if he will just read that short report.

Mr. G. C. Stephenson (Koppers Products Company):—This report covers the inspection made on the Santa Fe, and at this time the Sub-Committee wishes to express its thanks to the officials of the Santa Fe, and especially to Mr. Belcher, for his cooperation.

"Inspection of creosote and petroleum mixture treated ties between Southland, Texas, and Vaughn, New Mexico, was made October 22 and 23, 1931. This track showed many ties treated with 12-pound full cell mixture of 30 per cent creosote and 70 per cent petroleum installed in 1910, 5-pound Rueping creosote installed in 1910 and 1913, 7-pound Rueping mixture 50 per cent creosote and 50 per cent petroleum installed in 1913, and ties treated with straight petroleum installed in 1910.

"The ties remaining in track appear to be in generally good condition. The mixture treated ties are not excessively railcut nor checked. In this respect, they are in better condition than the ties treated with 5 pounds of straight creosote. A noticeable feature in a certain portion of the mixture treated ties, particularly those having 12-pound treatment, is an asphalt-like coating on the surface, often having small pieces of ballast imbedded in it.

"At Grier, New Mexico, in a passing track, a large number of 1913 7-pound 50/50 mixture treated ties were inspected and numerous fruiting bodies of fungus were found and identified as Lentinus lepideus, a wood destroying species. The ballast on this passing track is dirt and has a considerable growth of weeds and grass. The conditions at this point are probably relatively conducive to the growth of the fungus, as more moisture is retained than in a track which has clean ballast and is kept free from weeds, in which respect it differs from the main track.

"It is quite probable that the moisture content of ties in other portions of the track inspected is very low for long intervals of time between rains and, consequently, that the growth of fungi is greatly retarded.

"The rainfall in the territory between Southland, Texas, and Vaughn, New Mexico, is said to be from 30 to 10 inches annually, decreasing as one proceeds westward, and the altitude generally increases in the same direction from about 4000 feet to 6000 feet. The rains are usually short but heavy, and often followed by very hot weather. The mixture treatment undoubtedly gives good protection against rapid changes of moisture content, and hence against splitting and checking.

"In the track sections heretofore mentioned, practically all mixture treated ties are Rocky Mountain conifers, principally pine. There are no hardwood ties. It has been observed in other lines that the pine ties can acquire a protective coating from creosote-petroleum mixtures or creosote coal-tar solutions, but this is not usually found on hardwood ties.

"The Committee believes that all of the factors mentioned should be given due weight in attempting to evaluate the Santa Fe experience with creosote petroleum mixtures as a guide for its use elsewhere.

"It seems to be the general opinion of the members making the inspection that the mixture treatment gives excellent protection in this section of the country. However, several feel that an attempt should be made to locate ties treated with mixtures of creosote and petroleum in other sections of the country, as well as sections containing ties treated with mixtures of creosote and coal-tar.

"The section near Kingman, Arizona, was inspected October 24, and there is very little change in the condition of these ties since the inspection in 1929 and reported in the 1930 Proceedings.

"It is recommended that the Sub-Committee be instructed to attempt to locate test tracks, or certain sections of track in other parts of the country on which records have been kept and which contain ties treated with creosote coal-tar solutions, as well as mixtures of creosote and petroleum.

Chairman F. C. Shepherd:—That completes our report.

The President:—We want to express the appreciation of the Association for the splendid report, which we are sure will be of great assistance to each of us and to many others (Applause).

DISCUSSION ON RAIL

(For Report, see pp. 555–578)

Mr. Earl Stimson (Baltimore & Ohio):—Your Committee has several items on Revision of Manual to present, and recommends for adoption the following:

"1. That the definition appearing on page 139 of the Manual reading "Compound Fissure—A horizontal fissure which is developing extends into a plane other than horizontal,' be revised to read 'Compound Fissure—A horizontal split head which in developing extends into a plane other than horizontal.'

"2. That definition on same page reading 'Horizontal Fissure—A horizontal progressive fracture . . . etc.' be revised to read 'Horizontal Split Head (formerly termed Horizontal Fissure)—A horizontal progressive fracture . . . etc.' "

The third item is in connection with a plate which appeared in last year's report illustrating recommended typical branding and stamping, as shown under the heading: Typical Stamping Showing Recommended Data, Arrangement thereof and Design of Letters and Numerals to be Used. This heading was offered for approval, and was approved at the convention last year with the exception that the words "arrangement thereof" were omitted on account of the objections being raised by the several manufacturers. These objections, however, have since been withdrawn and it is recommended now that the words "arrangement thereof" appearing at the end of the first line under heading "Typical Stamping" on page 353 of the 1931 Proceedings, which words were eliminated at the last convention, be reinstated for publication in the Manual.

I move that these three revisions be adopted.

The President:—These are before you, gentlemen. Are there any questions?

Mr. H. D. Knecht (Missouri Pacific):—The Association as well as the individual railroads have for a number of years compiled statistics on different types of rail failures. I wonder if it is the intention by this recommendation that the horizontal fissure, formerly known as such, would lose its identity and go into the class as split head. It has taken an educational program to get the average trackman to properly report failures in the classification the Association and roads have already set up, and this distinctive type of failure, other than that known as an ordinary split head, would be lost if it is the intention of the Committee to put those two together in the one classification.

Chairman Earl Stimson:—The intention of the Committee is merely to change the designation from horizontal fissure to horizontal split head, because the type of failure is a split and not a fissure. There seems to be considerable confusion now between horizontal fissure and transverse fissure. The type of failure does not lose its identity at all, by merely changing its designation.

Mr. H. D. Knecht:—Would you like to have two classes of split heads and be able to get it properly reported as such? Progressively, we have been able to get the two types of fissures properly separated, and I wondered if we weren't going back to a proposition where it would be another matter of education in having two classes of split heads.

Chairman Earl Stimson:—In making the recommendation, the Committee does not anticipate any trouble of that kind.

Mr. C. W. Baldridge (Atchison, Topeka & Santa Fe):—It appeals to me that the term "fissure" should be confined to a transverse fissure only, and for that reason I offer an amendment to the motion before the house, that the revised definition given under Article (1), page 556, be changed to read: "Compound Fracture.—A horizontal split head which in developing extends into a plane other than horizontal," the only change being the substitution of the word "fracture" for the word "fissure" after the word "compound".

Mr. G. R. Westcott (Missouri Pacific):—I have seen a great many of what have been termed compound fissures. They are typical in character with the transverse fissure, and usually there is a transverse portion, and a portion extending in some other direction. It seems to me the project of changing this name is entirely wrong if we are to keep in a class by themselves those progressive fractures that we commonly identify as fissures.

The same thing will apply to No. 2, the changing of the name of "horizontal fissure" to "horizontal split head". While the character of that fissure is not exactly identical with the transverse, it is obviously a progressive fracture and has a characteristic appearance quite different from the appearance of the fracture that we commonly know as a split head. I would be disappointed to see either one of these changes made.

Mr. C. W. Baldridge:—If I may explain my reasons a little further, a true transverse fissure is a failure which the stresses in the rail develops from a rough spot nucleus in the head of a rail. The compound fissure, so-called, also develops from stresses in the rail of course, but its primary cause is not the rough spot nucleus. It is a flaw in the rail. The development is similar but the causes are entirely different, and there are two other types of failures which are very similar but the causes are different. The so-called head check rail starts from a crack in the outer edge of the rail. The development looks about the same as one-fourth of a transverse fissure, but the cause is different.

It is my opinion that the term "fissure" should be continued as applied to transverse fissures only, to make a clear distinction where the cause is different. I advocate changing "compound fissure" to read "compound fracture".

Chairman Earl Stimson:—I agree with you fully that the word "fissure" should be used only to designate a transverse fissure or used in connection with compound fissures which develop from a horizontal split head, but to apply the word "fracture" is not at all descriptive, because a fracture is any break regardless of source or regardless of kind.

I hope the Committee's recommendation prevails. They have given it a good deal of thought, and the Engineer of Tests, who handles all the rail failures statistics, and handles thousands of reports in his compilations each year, has found it necessary to have some more distinctive designation for the horizontal fissure to avoid confusion with the transverse fissure.

Mr. C. W. Baldridge:—I have felt that to the experts who are handling these rails it will be perfectly clear with either word, but the men in the field who are going to make the failure reports are much more likely to become confused as between the fissures if you carry two or three different types of failures under various terms of fissures. If the name were distinctive, I believe the men in the field, section foremen and roadmasters, would more quickly learn to distinguish between the true transverse fissure and various failures of a similar nature but from a different cause.

Chairman Earl Stimson:—The Committee is making the recommendation because it sensed that is the trouble now. They are confusing the horizontal and the transverse fissure. By a distinctive name that confusion will be overcome.

The President:—You have Mr. Baldridge's motion before you. Are there any further comments?

(The amendment was put to vote and lost.)

The President:—You now have before you the original motion of the Committee and their recommendation to include in the Manual certain changes, which has been seconded.

(The motion was put to vote and carried.)

Chairman Earl Stimson:—Mr. W. C. Barnes, Engineer of Tests of the Rail Committee, will now give a brief statement of the operating results of the A.R.A. transverse

fissure car for this year, and also of the rail failure statistics he has worked up for the year 1930.

Mr. W. C. Barnes (Engineer of Tests, Rail Committee):—During the past year the A.R.E.A. detector car was rebuilt due to weakness that developed in the underframing, and opportunity was taken at that time to make various improvements in the apparatus and equipment. The work was done at the Northern Pacific shops and very successfully carried out. The cost was paid for out of earnings and the car was put back into service, only 4 or 5 days being required for tuning up after completion of the rebuilding.

The car has been in constant demand since it was placed in service in 1928, and on November 6, 1931, it had tested a total of 11,133 track miles in which were detected a total of 988 transverse or compound fissured rails and 3,453 defective rails of all types. The average rate of detection from the start of operation to November 6, 1931, was one transverse or compound fissured rail per 11.3 track miles, and defective rails of all types were located at a rate of one per 3.2 track miles. The detection of 172 transverse or compound fissured rails and 412 defective rails of all types in 1,143 track miles, at respective rates of one per 6.7 and 2.7 track miles are indicative of the work done by the car since its rebuilding. This testing was done at an average rate of 16.5 track miles per testing day.

I just want to say that these averages would have been considerably higher if we had been operating in a different manner, but our leases, particularly in the beginning of operation were of very short duration, averaging about one week. Therefore considerable time was necessarily spent in transit and the leasing terms were too short to develop maximum working speed. Of late we have been testing for longer periods on individual roads.

I will call your attention a little later to the transverse fissure statistics which indicate the effect that the use of fissure detector cars is having on the stopping of the normal rate of increase of fissure failures in track.

This short report is submitted as information.

Rail Failure Statistics for 1930 are shown on page 559 of the Bulletin. These statistics have been prepared in the usual manner. They include the record of 50,222 track miles of rail rolled from 1925 to 1929 inclusive. They also include charts showing the rating of the mills at which these rails were rolled based on the average rates of failure.

It is interesting to note, as shown in Table 1, Fig. 1 on pages 560 and 561, that there has been practically no change in the average rates of failure of all reported rails rolled since 1921. In a way that is comforting. They have not become any worse, but they have not improved much, either. I will not go into the tables. They are self-explanatory. We submit the report as information.

The next report is that on transverse fissure statistics. These statistics constitute a cumulative record of 50,746, transverse fissure failures reported up to and including December 31, 1930. They include all fissured rails reported whether located by actual breakage in track or detected by inspection or test.

All data presented for the year 1930 cover eleven months only, from January 31, 1930 to December 31, 1930. This was occasioned by the change of the fiscal year being put into effect this year. Next year they will cover a 12-month period.

During the eleven months ending December 31, 1930, 6,711 fissure failures were reported, or an average of 20 such failures per day. This is an increase of 473 over the preceding year's total, which increase is more than accounted for by an increase of 956 in the number of detected fissures.

Your attention is called to Figure 1 on page 569 which indicates that the steady increase each year in the number of transverse fissure failures disclosed by actual break-

age in track or by inspection has been finally checked, which result is attributed to the removal of defective rails before breakage in track, and to the lighter traffic conditions existing during the past few years.

These statistics are fully described in the text and are submitted as information.

The President:—The report of Mr. Barnes' Sub-Committee is of great interest, and is received as information, if there is no objection.

Chairman Earl Stimson:—The Committee offers the balance of the report as information so that we can pass on to a real treat we have in store for you.

I feel you are all anxious to hear something about the transverse fissure rail investigation work that is being carried on jointly by the Rail Manufacturers' Technical Committee and the Rail Committee at the Engineering Experiment Station, University of Illinois. We are fortunate in having Dr. Moore with us today, who has the direction of this research work, and he will tell us something about it.

Prof. H. F. Moore (University of Illinois):—Mr. Chairman and Gentlemen: The joint investigation of fissures in rails, when it came into existence under the auspices of the American Railway Association and the Technical Committee of the Steel Manufacturers, began with an inheritance, in fact, two inheritances. These inheritances gave us some idea of the magnitude of stresses which we might expect in rails, not a precise knowledge but some idea. The first inheritance was the work done by Professor Talbot's Committee on Stresses in Railroad Track, which showed that the direct bending stresses which rails have to stand in service are decidedly high.

The second inheritance was a piece of mathematical analysis carried out under the auspices of the Utilities Research Commission of this city, in which a mathematical study was made, was checked by experiment, showing something of the theoretical stresses which exist in rail heads under wheel loads. The detailed results of that mathematical analysis are published in Bulletin No. 212 of the Engineering Experiment Station of the University of Illinois, which any of you can get by application, and showed that such stresses theoretically were very high—of the order of a shearing stress of 40,000 or 50,000 pounds per square inch under a 25,000-pound load on a 33-inch wheel.

With this background, we entered into some testing work more directly connected with the actual study of fissures. The material was, for the most part, new rails supplied by the joint committee from rollings whose history was very carefully known, and in which the inspection was very close. The data of all such inspection, of all such rollings, were furnished with the rails. So far there have been furnished 163 130-pound rails. In addition to this general material, we have accumulated quite a little material from rails which have developed fissures in service, rails which have been worn out in service without fissures, and other rails which seem to be of special interest.

The work which is being carried on may be divided roughly into four divisions. First of all, there are routine chemical and physical tests. We have, of course, heat analyses of all the rails, and whenever a rail is set aside for definite tests a check analysis of that rail is made. The physical tests include tensile tests, the record of drop tests at the mill, notched-bar impact tests, fatigue tests, and we are trying to get some tests on the damping quality of the steel under vibration—tests to show whether the steel vibration dies out quickly or slowly.

The physical tests so far show no very striking results. The ratio of the fatigue strength in reverse flexure to tensile strength is somewhat low, of the order of 40 per cent.

The second division of the work includes metallographic examination and etching tests. From each of the rails received one, two or three samples are cut out for a deep etching test. In Fig. 1 the head of the rail is seen at the extreme top of the picture, and the bottom is the base of the rail. The figure shows one way of showing the location of transverse fissures by cutting a vertical section.

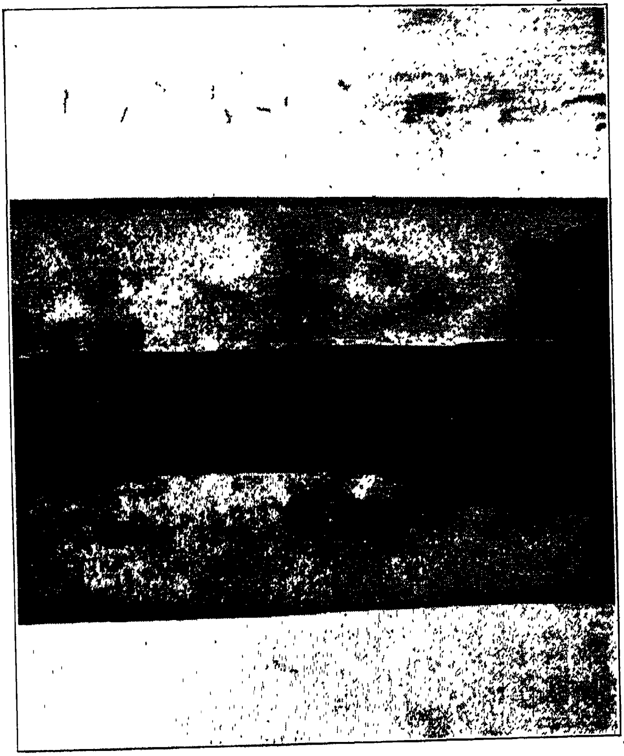


Fig. 1.—Result of Deep-etch Test of Shatter-cracked Rail.

Reduced to ⅔ size.
Vertical section of head a little outside of web.
Etched one-half hour in hot 50 per cent hydrochloric acid solution.

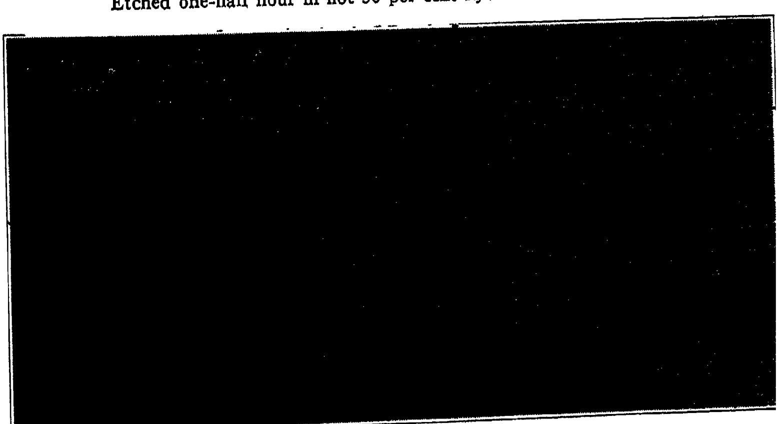


Fig. 2.—Result of Deep-etch Test of Head of Shatter-cracked Rail.

Full size.
Horizontal section near middle of depth of head.
Etched one-half hour in hot 50 per cent hydrochloric acid solution.

Fig. 2 shows the result of a common deep etch test on a horizontal section of a rail. So far, we have found that the surest way of finding whether there are shatter cracks in the rail is by using the deep etching process. In the 163 rails, there have been found four rails which had distinct transverse shatter cracks in them, three of them being from the same heat. Fig. 3 is from a micrograph taken with "dark field" illumination—illumination by means of oblique light so that light is reflected from the walls of cracks and the edges of scratches, which show bright in the photograph. Fig. 3 is a micrograph of an unetched section of a rail and the shatter crack is visible extending vertically across the middle.

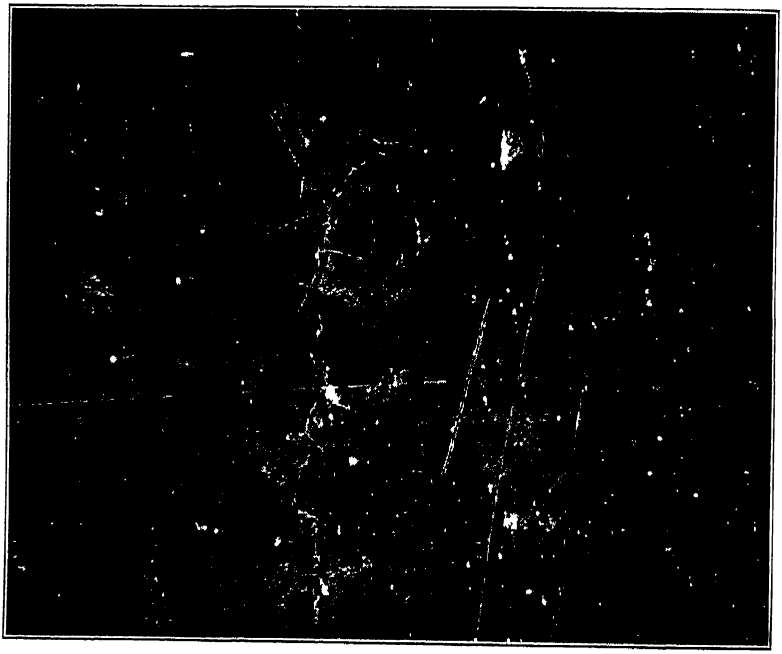


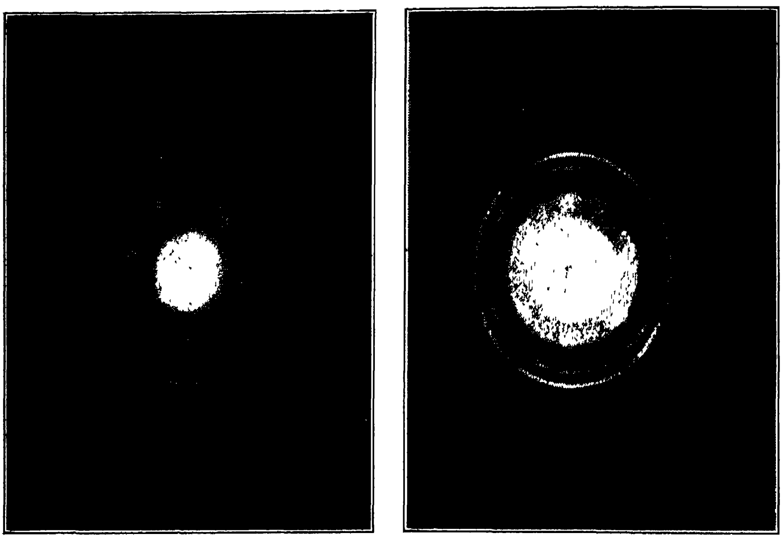
Fig. 3.—"Dark Field" Micrograph of Steel in Head of Shatter-cracked Rail.
Magnification, 500 times.
Unetched.
Shatter crack extends vertically across cut.

FIG. 4.—Micrograph of Steel in Rail Head.
Magnification, 2,000 times.
Etched with 2 per cent Picric Acid in Alcohol.

Fig. 4 shows the characteristic structure found in rails. A great many micrographs have been taken, nearly all of rails of about 0.80 per cent carbon steel. In a few cases evidences of a cementite network have been found, and in a few cases, in isolated areas, some traces of ferrite, but by far the larger part of the rail steel is found to be pearlite. Fig. 4 is a typical micrograph.

As we have X-ray facilities close to our laboratories, some study of X-ray analysis of rails has been made under the direction of Professor George L. Clark. An attempt was first made to locate small cracks, including shatter cracks, by X-rays, but so far the results have been negative.

Fig. 5 shows X-ray spectrograms taken in an attempt to study something of the internal structure of two thin strips of steel, the one at the right hand of the picture being a steel which is cut from near the edge of the rail, the one at the left hand being a strip of steel which is cut near the part where transverse fissures usually start. Speaking in terms of the X-ray man, the left-hand picture shows "asterism", which is indicated by a sort of "aurora borealis" effect in the figure, and from the X-ray man's study of cold-drawn steel he feels that this sort of appearance is usually caused by some minute fragmentation within the crystal, which shows up in such a picture. How serious it is, or what the magnitude of the strains causing it are, he cannot tell us at present. It is merely an interesting picture which we have taken as a matter of record.



(a) (b)

FIG. 5.—"Laue" X-ray Spectrograms of Steel in Rail Head.
(a) Steel from center of head.
(b) Steel from near the outside edge of the head.

The third division of our work is an attempt to produce in the laboratory transverse fissures in rails, or at least in rail heads. Fig. 6 shows the machine we have used in this respect. There is a crank having a 7-inch stroke, and the rail is pulled back and forth on a carriage under a 33-inch car wheel, which is pressed against the rail by a lever, and the calibrated spring at the end. This is a repeated stress testing machine for rails, and by supporting the rail in various ways we can put the head either in tension or in compression. The speed of the machine is 55 strokes per minute.

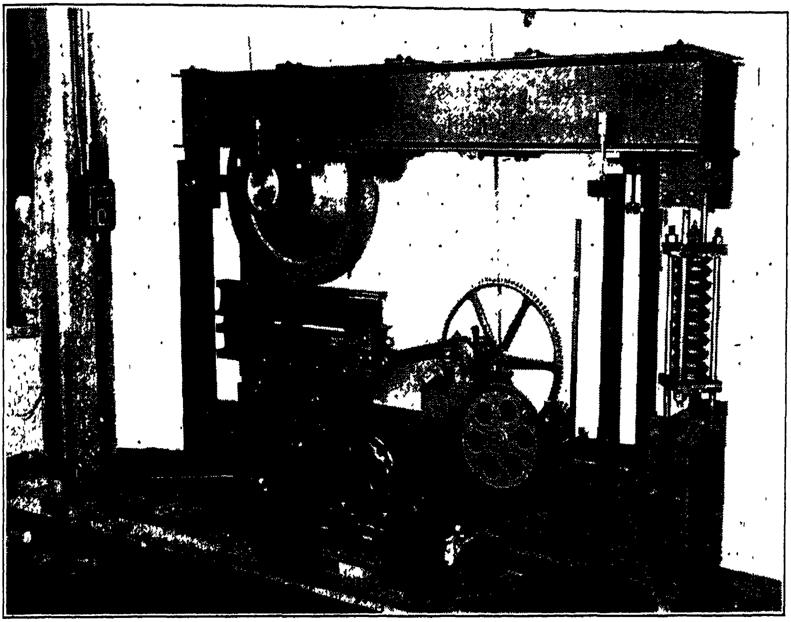


FIG. 6.—Rolling-bending Testing Machine for Rails.

With this machine, we have had what I sometimes think was the unfortunate experience of producing a well-marked transverse fissure with our very first specimen. This is shown in Fig. 7. The specimen was tested by cutting a longitudinal slot in the web, which for a distance separated the head from the rest of the rail, and applying bending to the head. The weight ran out so that the head was cantilevered and the top part

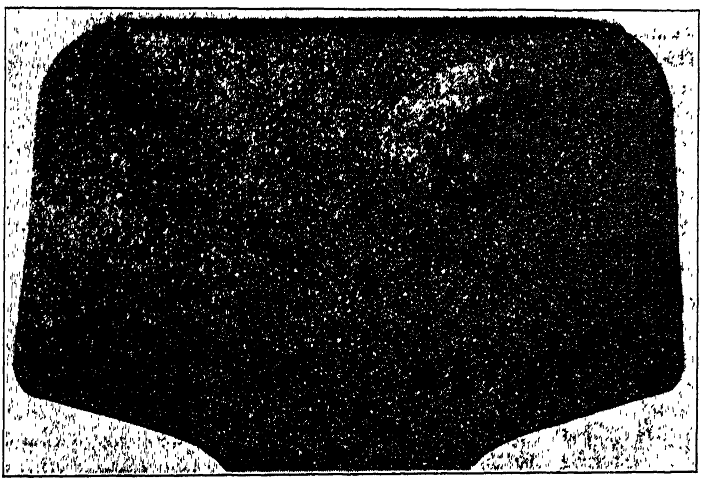


FIG. 7.—Transverse Fissure Produced in Rail-Head by Rolling-bending Test.

was in tension. The typical transverse fissure is seen in the upper right-hand corner. The computed tensile stress under which this broke was only about 30,000 pounds per square inch, but the various stresses, including the shearing, caused by the wheel load of 50,000 pounds were very much higher than this. Since that time, we have broken eight or nine other rail heads, but in all cases the failure has been by progressive fracture starting from the *surface*. It happened that this was a rail in which there were many shatter cracks. Whether the shatter cracks have anything to do with the production of this type of fissure, we are of course not ready to say yet.

In connection with these tests, we discovered one fact which to us at least was surprising. In the web of the rail directly under the wheel, the vertical compression is high. So far as we could figure there was no other heavy stress, and yet in these specimens there opened up a very definite fatigue crack in that web in a horizontal direction. Having found that rather surprising action, we at once set to work on small specimens and have succeeded in producing definite fatigue cracks in flexure specimens on the side subjected to cycles of nominal compression. As the heaviest stresses which come in the heads of rails are compressive, it would seem that this might be of some significance.

The fourth division of our work is one in which we have barely made a beginning, and on which we have to report only trials of methods, with negative results so far. This is the attempt to detect by some non-destructive method shatter cracks or other cracks in new rail, and the method which we have used so far is the drop of potential method, essentially the same method as is used for the final check-up with the well-known Sperry apparatus. Since we are working in a laboratory it is convenient to use the drop-of-potential method at first, instead of using a quicker method and then checking it by this.

In checking the drop-of-potential method in the usual way we used the apparatus we had set up on some rails in which fissures had been detected by the Sperry car, and we checked those fissures. Since that time we have other check tests, and have found fissures when the rails tested were broken, but, when the drop-of-potential method was applied to new rails in which deep etching had shown shatter cracks, negative results were obtained. Then, thinking that the opening up of shatter cracks might be facilitated by bending, we bent a pair of rails until the heads were stressed to about 30,000 pounds per square inch tension. Then running the drop-of-potential method, we got no indication of shatter cracks.

Thinking possibly the resistance of the rail might change as the head was stressed in tension, we took readings of the drop-of-potential along the whole rail without stress, and with stress, and again found negative results. Not being quite satisfied with that, we carried this on in more delicate, smaller sized apparatus, using small specimens, and actually got to the point where although a crack in the specimen was visible to the unaided eye, yet we could not detect increase of drop-of-potential. So this drop-of-potential method, so far as we have followed it, seems to be limited to the detection of fissures somewhat larger than these shatter cracks which are sometimes found in new rail.

We can only report plans for working this particular branch of the investigation. We wish to try several schemes. There may be possibilities in electrical measurements using alternating current in the hope that the inductance and impedance around small cracks will create more disturbance than the mere variation in resistance. Then there are accoustic methods following the lines laid down by Mr. Kinzel of the Union Carbide and Carbon Company in investigating cracks in welds. He claims to be able to detect cracks with an ordinary stethoscope, although it takes considerable practice and a keen ear to become skillful. There is a possibility that instead of the human ear a microphone may be applied to the stethoscope and we may get more reliable results.

We are having some preliminary tests made for us on the damping of vibrations in specimens cut from steel rails of various known histories. These are being made by Dr. von Heydekampf at the Baldwin–Southwark laboratory, and we wish to see if his apparatus shows any difference in damping between rail steel from rails which have shown transverse fissures, from new rails which had shatter cracks in them, and new rails which, so far as we can see, do not. We have not as yet received the results of those tests, but if they show anything we may add this test to our methods of study.

If all these methods fail, there yet remains the possibility of detecting small cracks in rails by the process of heating a rail slightly, 20, 30 or 40 degrees Fahr. above atmosphere, and then hunting for variations of temperature over the cracks with a very delicate thermocouple.

This is emphatically just a report of the beginning of the investigation. Perhaps it is an extension of courtesy to call it even a report of progress. We certainly have drawn no final conclusions. We have produced a transverse fissure in the laboratory in a rail which had shatter cracks, but we do not know what connection there may be between transverse fissures and shatter cracks. It is obvious that rail steel is not a homogeneous material, and that it has various kinds of defects. How serious they are in producing transverse fissures, we do not know.

It is equally obvious that, considering the stresses produced in service, rail steel gets hard, trying treatment. Theoretical stresses at their worst are not quite as high as are the fatigue strengths developed in laboratory specimens. How much the service stresses have to do with the production of transverse fissures; how much the conditions in the steel have to do with it, are questions which, from our viewpoint, are distinctly unsolved.

The President:—Professor Moore, I want to express the appreciation of the convention, and of all the members and myself for the excellent progress report on this interesting subject, and the fine manner in which you presented data. We will look forward to this work as being of great saving and help to the rail manufacturers as well as to the railroads.

Thank you, Mr. Stimson, for the splendid report of your Committee which you have presented (Applause).

DISCUSSION ON TRACK

(For Report, see pp. 579–586)

Mr. C. R. Harding (Southern Pacific):—Thank you for your introduction, Mr. President.

Bulletin 344, page 580, Subject (1), Revision of Manual. The Committee recommends revision of the pages of index as listed, and for the reasons shown in the printed text.

The Committee recommends revision of Plans 273 to 279.

The Committee recommends revision of Plans 401, 402, 403 and 404.

The Committee recommends that Plan 501 be withdrawn.

The Committee recommends revision of Plan 502.

The Committee recommends that Plans 305, 308, 321 and 420 be withdrawn, as they are no longer needed.

The Committee also recommends the revision of track tool Plans 1, 2, 6, 8, 9, 10, 12, 17, 18, 19 and 21. The revisions are mostly of minor importance.

I move that the Committee's recommendations be adopted.

(The motion was regularly seconded, put to vote and carried.)

Chairman C. R. Harding:—Subject (1-A) will be submitted by Mr. E. D. Swift, Chairman of the Sub-Committee.

Mr. E. D. Swift (Belt Railway of Chicago):—Report of the Sub-Committee consists of three matters occurring under Appendix B, page 581 of Bulletin 344.

On the first matter, it is proposed to dispose of a matter that the Sub-Committee has had under consideration of establishing tolerances for tie plate shoulder height.

The action which is proposed, and the reasons for it are printed in full, and it is moved that the recommendation be approved.

(The motion was regularly seconded.)

The President:—You have heard the motion, gentlemen. Is there any discussion?

(The motion was put to vote and carried.)

Mr. E. D. Swift:—The second matter the Committee has had under consideration is specifications for malleable iron tie plates. This is offered as information.

The President:—It will be so received, unless there are objections.

Mr. E. D. Swift:—The third matter the Committee has under consideration is changes in specifications for soft steel track spikes. Progress is reported.

The President:—It will be so received.

Chairman C. R. Harding:—On Subject (2), String Lining of Curves by the Chord Method and Preparation of Tables Suitable for the use of Trackmen, the Committee reports progress.

Subject (3) will be presented by Mr. G. M. Strachan, Chairman of the Sub-Committee.

The President:—Subject (2) will be received as recommended, unless I hear objection.

Mr. G. M. Strachan (Atchison, Topeka & Santa Fe):—On page 582, under Appendix D, is found Plans and Specifications for Track Tools.

In the 1929 Supplement to the Manual, Plan No. 4, dated September, 1929, covers wrenches for old style nuts. Plan No. 4-A, dated February, 1930, is submitted herewith as new plan to cover wrenches for the new style A.S.A. nuts.

The Committee has given further study to the chemical and physical specifications for track tools, also specifications covering hickory handles, but is not yet in position to make definite recommendations. Plans covering track shovels and ballast forks are also under consideration.

The Committee recommends that Plan No. 4-A, submitted herewith, be adopted as recommended practice and printed in the Manual, supplementing present Plan No. 4 for old style nuts.

The President:—You have heard the motion. Is there any discussion?

(The motion was put to vote and carried.)

Chairman C. R. Harding:—Subject (4), page 583, Plans for Switches, Frogs, Crossings, Slip Switches, etc., will be reported by Mr. O. F. Harting, Chairman of the Sub-Committee.

Mr. O. F. Harting (Terminal Railroad Association of St. Louis):—During the year this Sub-Committee prepared quite a number of new plans. The report is found on page 583 under Appendix E.

The new plans, as well as those given in the Revision of the Manual under Appendix A coming under this subject, have been prepared in conjunction with the Standardization Committee of the Manganese Track Society. This Society is composed of the various frog and switch manufacturers of the United States; the assistance received from these manufacturers is of a very valuable nature.

Last year the Committee presented as information, to invite criticism, Plans 260 and 262, showing general details of the various types of No. 8 and No. 10 frogs for medium weight rails with uniform tie spacings for one-piece manganese and other guard

rails. All subsequent suggested changes that were agreed upon have been incorporated in Plan 262 and it has been rearranged so that it will reproduce on a standard size A.R.E.A. sheet without fold. Taking Plan 262 as typical, the entire series, Plans 256 to 269 inclusive, has been completed.

This series of plans corresponds to the series of plans of frogs for heavy rails heretofore adopted, Nos. 271 to 279 inclusive, 281 to 283 inclusive, and 291 and 292.

Plan 326, showing details of tie plates and base plates for railbound manganese steel, bolted rigid and solid manganese steel frogs for medium weight and heavy rails, is submitted herewith for adoption as recommended practice.

Plans 503 and 504 of Guard Rails, tee-rail design respectively, with bent and planed flares, are submitted herewith for adoption as recommended practice. These plans supersede previously adopted Plan 501 showing details of guard rails, which plan is recommended for withdrawal in Appendix A.

I move for adoption as recommended practice Plans 258 to 269 inclusive, showing frogs of various numbers for medium weight rails for railbound manganese steel, bolted rigid, spring rail, and solid manganese steel.

The President:—You have the resolution before you, gentlemen. Are there any comments or questions?

(The motion was put to vote and carried.)

Mr. O. F. Harting:—I further recommend for adoption Plan 326 showing details of tie plates and base plates for railbound manganese steel, bolted rigid and solid manganese steel frogs for medium and heavy weight rails.

(The motion was regularly seconded, put to vote and carried.)

Mr. O. F. Harting:—I further move for the adoption of Plans 503 and 504 showing guard rails, tee rail design (503) for bent flares and (504) with planed flares.

The President:—You have the motion before you. Is there any discussion?

(The motion was put to vote and carried.)

Mr. O. F. Harting:—The Committee further recommends that Plans 256 and 257, showing frogs for medium weight rails, railbound manganese steel, bolted rigid and solid manganese steel for No. 4 and No. 5 frogs be received as information.

The President:—Unless there is objection, it will be so received.

Chairman C. R. Harding:—Subject (5) will be reported by Mr. E. W. Caruthers, Chairman of the Sub-Committee.

Mr. E. W. Caruthers (Pennsylvania):—The report of the Sub-Committee will be found on page 585 of Bulletin 344, and the Committee wishes to offer as information plans which are shown in the Bulletin: No. 987, dated November, 1931, showing A.R.E.A. Straight Double Tongue Switches for engine wheel base not over 14 ft. 6 in.—Solid Manganese Steel—for Use in Paved Streets, 7 in. and 9 in. Girder Rails; also No. 988, dated November, 1931, showing A.R.E.A. Straight Double Tongue Switches for engine wheel base over 14 ft. 6 in. but not exceeding 19 ft. 0 inches—Solid Manganese Steel—for Use in Paved Streets, 7 in. and 9 in. Girder Rails.

These plans have been prepared with the assistance of the Manganese Track Society and are offered this year as information only.

The President:—Unless there are objections, it will be so received.

Chairman C. R. Harding:—On Subjects (6), (7) and (8)—I will not take the time to read the titles—the Committee reports progress.

The President:—Unless there is objection, it will be so received.

Chairman C. R. Harding:—Subject (9), Standard Wheel Flanges, Treads and Gages, will be reported on by Mr. J. V. Neubert, Chairman of the Sub-Committee.

Mr. J. V. Neubert (New York Central):—This report is covered on page 586, Appendix J, Standard Wheel Flanges, Treads and Gages.

This subject has been under discussion for the past three or more years. Many joint conferences have been held between this Sub-Committee, representatives of the Mechanical Division of the A.R.A., and representatives of the Association of Manufacturers of Chilled Car Wheels. Measurements of the actual conditions that exist in track on certain railroads have been surveyed for both new and old wheel equipment, and for new and worn track conditions, from which composite diagrams have been prepared.

Among other data, field measurements disclosed frogs with flangeway 1⅝ inches wide or less as follows:

In major track	32 in 191 examples taken
In secondary track	69 in 142 examples taken

Since this Bulletin has come out, the Committee has had under consideration to change the report recommended in the Bulletin.

Paragraph 1, Plan No. 790, dated September, 1931, Serial No. 32, specifies 1⅞-in. flangeway width as an alternate. It is suggested that this flangeway could be practically met without an alternate by adopting a 1 13/16-in. standard flangeway width with a manufacturing tolerance per present specification A.R.E.A., Appendix B, section 33—"the width of flangeways may not be less than specified nor more than 1/16-in. wider than specified".

It is also recommended for maintenance that a minimum guard check gage of 4 ft. 6½-in. be added in Paragraph 2, for if no minimum is specified considerably more latitude than ⅛-in. would be taken. For instance, over 400 measurements taken in track on nineteen different railroads, including all the principal systems radiating from Chicago, showed guard check gage less than 4 ft. 6½-in. on about 10 per cent of the measurements and less than 4 ft. 6⅝-in. on approximately 25 per cent of the measurements. The 4 ft. 6½-in. minimum for guard check gage is for maintenance only, which it has been found will give protection for worn frogs as frog points become depressed approximately 3/16-in., if not furnished with wing wheel risers, after the first few heavy trains have run over them.

Wider Flangeway Explained.—The effect of vertical wear (considering the average wear on treads of wheels, before removal, plus the average wear of tread surfaces of track work that is maintained to standard 4 ft. 8½-in. gage) proves that an initial 1¾-in. flangeway width is too small and that 4 ft. 5-in. guard face gage is too large to prevent binding.

The need for wider flangeway, particularly in manganese construction, is emphasized as the flangeways of new frogs or crossings close in approximately ⅛-in. due to flow of the metal in the first few weeks of heavy service and much more slowly later. In order to maintain minimum 1⅝-in. flangeway for a reasonable length of time without grinding an initial flangeway of 1 13/16-in. is necessary.

It is believed this will add to the life of track work by largely avoiding undue strains and distortions not only in the track structures, but also in the wheels and axles.

Revisions.—The changes in plan No. 790 are shown on alternate dated Revised March, 1932, Serial No. 32-B. They consist of:

Withdrawing present Paragraph 1 and substituting new Paragraph 1, as follows:

> "Revise A.R.E.A. plans for Frogs and Crossings where 1¾-in. flangeway is shown, to specify standard flangeway of 1 13/16-in. in Frogs and maximum guard face gage 4 ft. 4⅞-in. in *New* Crossings."

Revise Paragraph 2 by adding minimum guard check gage shall be 4 ft. 6½-in.
Withdraw Paragraph 3 and substitute new Paragraph 3, as follows:

"Where gage of track in *new work* is widened for curvature to prevent binding of wheels the maximum guard face gage of 4 ft. 4⅞-in. should be decreased also to prevent binding. In this connection see Plans Nos. 791 and 792 for gages and flangeways in curved track."

Withdraw present note in black face type following Paragraph 3.

CONCLUSIONS.—With the revisions as specified above, it is recommended that this report be received as information, and the subject be continued.

The President:—Unless there are objections, the report will be so received and handled.

Chairman C. R. Harding:—That completes the report of the Committee on Track.

The President:—The report shows that your Committee has not been idle. They have done a lot of work, and you are to be congratulated (Applause).

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